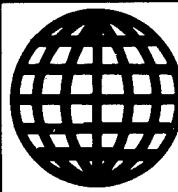


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# **Science & Technology**

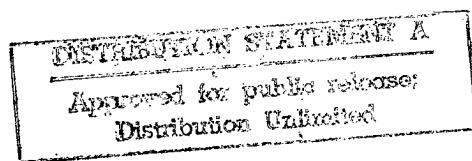
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# Science & Technology

## USSR: Physics & Mathematics

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UDC 534.8:539.3

**Evolution of Zinc Structure Following Deformation by High-Intensity Ultrasound**

18620212B Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 34 No 5, May 89 (manuscript received 9 Nov 87, in final version 9 Feb 88) pp 727-730

[Article by N. P. Pilipenko and T. A. Ryumshina, Donetsk Institute of Engineering Physics, UkrSSR Academy of Sciences]

[Abstract] An experimental study concerning ultrasonic treatment of zinc was made, bar specimens hydraulically extruded from extrahigh-purity 99.95 pct Zn castings and allowed to recrystallize after long recovery at room temperature having been subjected to ultrasonic treatment at a frequency of 22 kHz at room temperature without cooling. The length of a specimen was 90 mm, equal to half the wavelength of the ultrasound, and its cross-section was 7 mm square. Ultrasound was generated by a magnetostrictive converter and transmitted to a specimen through a threaded connector. Its intensity was controlled by means of an electrodynamic regulator mounted on a conical concentrator which had been calibrated under an optical microscope. The amplitude of vibrations at the center of a specimen was  $1.10^{-4}$  m, irreversible scattering of sound energy during deformation beyond the yield point resulting in an appreciable rise of the internal temperature up to 360 deg C and consequently in compounding the mechanical high-frequency cyclic load with a thermal ultrasonic load. The evolution of defectiveness in the zinc bar structure depending on the duration of ultrasonic treatment up to 15 min, at a constant high intensity, was tracked by selective etching of the surface for microstructural examination under a microscope with  $\times 250$  magnification and microhardness testing. Cracking and intragranular slippage were found to cause comminution of grains, most appreciably at the center and hardly at all at the ends of a bar, the structure becoming ordered with grains elongated in the direction of ultrasound propagation prior to fracture. Figures 3; references 6: 5 Russian, 1 East German.

**Nonexistence of Centrisymmetric Shock Waves in Empty Space According to Relativistic Gravitation Theory**

18620238B Moscow TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian Vol 79 No 3, Jun 89 (manuscript received 20 Apr 89) pp 473-480

[Article by A. V. Genk, Leningrad Scientific-Industrial Association 'Burevestnik' (Drilling Operations Bulletin)]

[Abstract] With the aid of Petrov's solution to the system of equations of the relativistic gravitation theory, Birkhoff's theorem stating that any centrisymmetric

field in empty space must be static is extended to nonexistence of spherical shock waves. It is demonstrated that the Petrov metric for spherical waves necessarily yields a static solution for empty space. The author thanks A. A. Logupov for comments, K. V. Anisovich and A. A. Grib for discussion. References 16: 11 Russian, 5 Western.

**New Mechanism of Sound Amplification in Weakly Ionized Gas**

18620207A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 5, May 89 (manuscript received 31 May 88) pp 1614-1624

[Article by N. L. Aleksandrov, A. M. Konchakov, A. P. Napartovich, and A. N. Starostin, Moscow Institute of Engineering Physics]

[Abstract] A friction mechanism of sound amplification in a weakly ionized gas is proposed, electrons still playing the principal role in acceleration of a shock wave and diffusion of its front. Theoretical analysis of this apparently anomalous phenomenon is based on the equations of motion and continuity for a gas in an electric field, the behavior of neutral particles being described according to conventional theory of gas dynamics but taking into account friction between them and charged particles. Considering that in such cases only a small fraction of the electron energy is transferred to atoms or molecules upon collision and that the frequency of electron-electron collisions is very low, those equations are solved for sound waves propagating along or across the electric field in the two cases of a much smaller than unity and a much larger than unity product of electron energy relaxation frequency electron charge relaxation time representing necessary conditions for sound wave amplification and attenuation respectively. Amplification of sound waves requires, moreover, that the electron diffusion coefficient be negative. Both amplification and attenuation of sound waves propagating along the electric field are shown to become anomalously large when the electron drift velocity depends weakly on the quotient of electric field intensity by concentration of neutral particles. References 27: 21 Russian, 6 Western.

UDC 03:04

**Forerunner of Shock Wave in Glow-Discharge Plasma**

18620206A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 8, 26 Apr 89 (manuscript received 9 Mar 89) pp 55-60

[Article by I. V. Basargin and G. I. Mishin]

[Abstract] An experimental study of shock waves propagating through a vertical glow discharge has revealed threshold conditions for formation of a forerunner. In a

plasma column 100 mm in diameter under a pressure of 33 torr, with a discharge current of 1.1 A and with a 1400 K temperature along the axis, the threshold shock-wave entrance velocity above which a forerunner will form was found to be 600 m/s. The evolution of such a forerunner preceding a shock wave which has entered the plasma column at a velocity of 1100 m/s was tracked on oscilloscopes with the aid of a transducer facing the shock wave. The forerunner did not retain a steady form in the plasma, a low-pressure zone behind it indicating that it

had departed from the shock wave. Both forerunner and shock wave exited the plasma at a supersonic velocity of approximately 1.5 Mach, the forerunner then retaining its form and the shock wave diffusing. Charged particles and not the temperature gradients are evidently responsible for the forerunner phenomenon. Analogous experiments in air plasma and in argon plasma yielded analogous results, molecules evidently also not playing a role in this phenomenon. Figures 2; references 11: 10 Russian, 1 Western.

### Spectroscopy of Phase Transition in T1GaSe2

18620155A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 12, Dec 88 (manuscript received 6 Jul 88) pp 3616-3620

[Article by V. M. Burlakov, Sh. Nurov, and A. P. Ryabov, Institute of Spectroscopy, USSR Academy of Sciences, Troitsk (Moscow Oblast)]

[Abstract] An experimental study of phase transition in lamellar T1GaSe2 ferro-electric crystals with Fe impurity was made in which reflection spectra of the lattice and absorption spectra of the impurity were recorded at temperatures ranging from room temperature to 10 K, the purpose being to establish the temperature of structural phase transition around an impurity center involving deformation of the Ga4Se10 polyhedron and indicated by a change in the optical properties of impurity centers. Absorption spectra covering the 560-720 cm<sup>-1</sup> region were recorded with an AVIKS high-resolution spectrometer, with a 0.08-0.14 nm resolution. Reflection spectra including the 248 cm<sup>-1</sup> band were recorded by the applicable infrared method, with and without impurity in the lattice. The absorption band was found to split into a triplet upon cooling, at least two bands appearing already at 200 K and the third one certainly below 130 K. As the temperature was lowered, the distance between them was found to increase while their half-width decreased. The results indicate a deformation and thus an instability of "rigid" Ga4Se10 groups, contributing to instability of the T1GaSe2 crystal lattice prior to phase transition. The authors thank I.M. Nekrasova for supplying the T1GaSe2:Fe specimens, V.A. Myzina for determining the distribution of Fe impurity, and A.P. Levanyuk for critical discussion of the results with several helpful comments. Figures 6; tables 1; references 6: 5 Russian, 1 Western.

### Galvanomagnetic Characteristics of Disordered GaSb at Low Temperatures

18620155B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 12, Dec 88 (manuscript received 3 May 88, in final version 25 Jul 88) pp 3691-3696

[Article by S.V. Demishev, Yu.V. Kosichkin, A.G. Lyapin, N.Ye. Sluchanko, and S.Ye. Chernyak, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of amorphous and crystalline GaSb mixtures was made involving measurement of their electrical resistivity in the Institute's "Solenoid" test stand at temperatures covering the 300-1.7 K range in a magnetic field of up to 150 kOe intensity. Measurements were made on specimens with 3:7 and 7:3 ratios of amorphous phase to crystalline phase, superconductivity being of particular concern. An interpretation of all data on the basis of the Allender-Bray-Bardin model indicates a tunnel mechanism of exciton superconductivity. Further analysis of the data indicates also that attaining superconductivity at temperatures below

the critical corresponding to zero electrical resistivity requires a high degree of dispersion but that the attendant high degree of localization produced by "jaggedness" of the random potential tends to suppress superconductivity prior to current flow, most likely by the mechanism of Coulomb repulsion. The authors thank A.A. Minakov and Yu.V. Bugoslavskiy for performing magnetic measurements, V.L. Larchev and G.G. Skrotska for supplying specimens of amorphous GaSb, and S.V. Popova for many helpful discussions. Figures 6; tables 1; references 9: 5 Russian, 4 Western.

### Radiation Emission by Ultrarelativistic Electrons in Quartz Single Crystal

18620148A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 48, No 11, 10 Dec 88 (manuscript received 5 Nov 88) pp 577-580

[Article by R.O. Avakyan, A.E. Avetisyan, V.A. Gyurdzhyan, K.R. Dallakyan, S.P. Taroyan, A.R. Mkrtchyan, R.A. Gasparyan, R.G. Gabrielyan, A.G. Mkrtchyan, and R.P. Vardapetyan, Yerevan Institute of Physics, and Institute of Application Problems in Physics, ArSSR Academy of Sciences]

[Abstract] An experimental study of radiation emission by ultrarelativistic electrons channeled through piezoelectric alpha-quartz single crystals was made, the purpose being to determine its energy spectrum and the dependence of the latter on the crystal thickness. The experiment was performed in the Yerevan synchrotron, a 4.5 GeV electron beam with a divergence of only 4.4.10<sup>-5</sup> rad being channeled along the 100-axis or in the (011) plane through 1 mm, 2.9 mm, 3.5 mm, and 6 mm thick X-cut crystals. After being recorded by a coordinate detector and having passed through the target crystal inside a vacuum goniometer, the electrons were separated by a magnet from gamma-quanta emitted by them and diverted to a telescoping set of scintillation counters while the gamma-quanta proceeded straight to a NaI total-absorption spectrometer. Electron energy of 4.5-2.7 GeV was recorded along with corresponding 0-1.8 GeV gamma-quantum energy. The emission spectra of axially channeled and planarly channeled electrons were found to have a peak, axially channeled electrons emitting harder gamma-radiation. The spectra of both but more those of axially channeled electrons were found to become broader and to shift toward higher frequencies with increasing crystal thickness, evidently due to an increasing probability of the spectrometer recording simultaneously emitted quanta and adding their energy, due to increasingly stronger quasi-channeled suprabARRIER and coherent bremsstrahlung emitted by scattered electrons, and due to rechanneling of quasi-channeled electrons. Figures 3; tables 1; references 3: 2 Russian, 1 Western.

**Semiconductor-to-Metal Phase Transition Induced in InSb by Strong Electromagnetic Field**

*18620146A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 1, 2 Dec 88 (manuscript received 11 May 88) pp 101-113*

[Article by G. G. Gromov, V. V. Kapayev, Yu. V. Kopayev, and K. V. Rudenko, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] An experimental study of transition from normal-pressure semiconductor phase to high-pressure metallic phase induced by a strong electromagnetic field of laser radiation was made, InSb having been selected as the target material on account of the appearance of metastable phases in it under normal conditions as well as after quenching. As source of electromagnetic radiation served a YAG:Nd<sup>3+</sup>-laser emitting 1,064 nm radiation in pulses of 10 ns duration. The target specimens were 0.35-0.40 mm thick wafers cut from InSb single crystal with (100), (111), or (211) orientation and class-14 surface finish obtained by dynamic chemical polishing, also 50-100 nm thick polycrystalline films deposited by vacuum evaporation on high-resistivity Si substrates. Laser action was monitored with a He-Ne laser by measurement of the reflection coefficient for 632.8 nm radiation after incidence of YAG:Nd<sup>3+</sup>-laser pulses on the target at liquid-nitrogen temperature and then at temperatures up to 323 K. The surface topography was examined under an REM S-800 scanning electron microscope and with a "TALYSTEP" profilometer. The chemical composition and depthwise profiles of In and Sb distributions were determined on the basis of Auger-electron spectroscopy involving layerwise etching with an Ar<sup>+</sup>-ion beam. Structural examination was done in an EG-100 kV transmission electron diffractometer and by the Debye method in an x-ray diffractometer with glancing incident radiation from a CuK<sub>α</sub> source at 77 K temperature. The dependence of the reflection coefficient on the pulse energy and on the number of pulses reveals a saturation effect followed by a decrease of the reflection coefficient at low temperatures, up to 4 pct at 77 K, this decrease becoming smaller at higher temperatures and vanishing above 250 K. This trend, and indicator of changing surface conditions and attendant phase transitions, is interpreted in terms of the mechanism of nonequilibrium phase transition and the exact integral theory of diffraction. The authors thank V. F. Degtyareva, Yu. O. Mezhenniy, and S. V. Zhuk for assistance in the experiment. Figures 7; references 24: 16 Russian, 8 Western.

**Role of GaAs(110) Surface 'Derelaxation' in Formation of Schottky Barrier With Ag AT 10 K Temperature**

*18620146B Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 12, Dec 88 (manuscript received 27 Apr 88) pp 270-275*

[Article by V. Yu. Aristov, I. L. Bolotin, and V. A. Grazhulis, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] An experimental study of GaAs(110)-Ag Schottky barriers was made involving ultraviolet photoelectron spectroscopy of an n-GaAs(110) surface during deposition of an Ag film at 10 K and then at 300 K temperature under an ultrahigh vacuum of 4.10<sup>-10</sup> torr. The energy spectra of the density of electronic states around the Fermi level revealed a new B-peak of surface states in addition to the A-peak of surface states and the C-peak of valence-band subsurface state, the amplitudes and the shifts of these peaks indicating changes in the energy band structure during the deposition process and depending on the temperature as well as on the thickness of the Ag film. During buildup of an Ag film on the GaAs(110) surface at 10 K temperature there evidently occurs a derelaxation of that surface, a B-peak corresponding to a nonrelaxed surface appears, increases linearly to a maximum, and then decreases exponentially as the film thickness increases. In the meantime, the A-peak corresponding to a relaxed surface free of atomic impurity decreases and vanishes. The experimental data confirm earlier numerical calculations based on the Bardeen model of a Fermi level pinned to intrinsic surface states of a derelaxed surface. Figures 5; references 15: 5 Russian, 10 Western.

UDC 669.245

**Fractal Kinetics of Creep in Solids**

*18620147A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 11, Nov 88 (manuscript received 24 Feb 88 in final version 14 Jun 88) pp 3384-3394*

[Article by A. I. Olemskoy, Institute of Strength Physics and Materials Science, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] A theory of creep kinetics in solids is constructed according to a unified model which includes thermal activation mechanisms with a hypothetically fractal profile of the thermodynamic potential in the configurational state-of-strain space. The creep process is regarded as a non-Markovian chain of jumps along successive minima of that fractal profile and strain levels are treated as interdependent steps on a hierarchical ladder rather than separate events. This model, based on an analysis of experimental deformation data and thermodynamic potential measurements, fits the concept of defects at one level merging into clusters which determine events leading to the next level. Following introduction of a Cayley tree and an ultraparametric space for a defect flux split into its drift and diffusion parts, a probabilistic correlator for the structural factor is defined in this space which consists of a thermal fluctuation component and an athermal one at each temperature. An analysis of this correlator and its asymptotic behavior in time yields an exponentially decreasing rate of transient creep. An overall creep diagram is plotted in the stress-temperature plane depicting the successive temperature ranges of reversible creep, transient and then steady irreversible creep, steady dislocation creep,

and steady vacancy creep. Figures 4; tables 1; references 14: 3 Russian, 11 Western (1 in Russian translation).

UDC 539.2:621.315.592

**Isotopic Study of Silicon Concerning Nature of Hydrogenous Centers**

*18620152B Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 50 No 2, Feb 88 (manuscript received 11 Nov 87) pp 336-338*

[Article by S. Zh. Tokmoldin, B. N. Mukashev, and M. F. Tamendarov]

[Abstract] In connection with the use of atomic hydrogen for passivation of high-level and low-level states in silicon, a study of radiative centers in silicon where H-atoms form valence bonds with Si-atoms was made by

the isotope method involving replacement of hydrogen with deuterium. The infrared absorption spectra of high-purity Si single crystals were recorded at 300 K and 80 K temperatures, after 12.5 MeV protons or deuterons, up to  $3 \cdot 10^{17} \text{ cm}^{-2}$ , had been implanted at 300 K. These spectra containing Si-H bands were analyzed, after perturbation of Si-H and Si-D bonds by polarization of their dielectric surrounding had been taken into account and accordingly anharmonic correction been added to the frequencies of their harmonic vibrations. The spectra of k-Si:H and k-Si:D reveal frequency shifts approximately twice as large for vacancy centers above  $2000 \text{ cm}^{-1}$  as for interstitial centers below  $2000 \text{ cm}^{-1}$  upon cooling from 300 K to 80 K, no absorption bands corresponding to flexural vibrations of Si-H bonds having been found within the  $700\text{-}900 \text{ cm}^{-1}$  range. Figures 2; tables 1; references 9: 2 Russian, 7 Western.

**Ionization Energy Losses During Propagation of 266.1 nm Laser Radiation Through Gases**

*18620197C Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 7, 12 Apr 89 (manuscript received 8 Feb 89) pp 64-68*

[Article by Yu. V. Anishchenko]

[Abstract] An experimental study was made concerning ionization of gases by ultraviolet laser radiation, specifically of dry air consisting of He, N<sub>2</sub>, CO<sub>2</sub> in a 1:1:1 ratio by 266.1 nm fourth-harmonic radiation from a YAG:Nd<sup>3+</sup> laser. Measurements of the electron concentration in such air have yielded its dependence on the molecule concentration or air pressure and on the power density of passing radiation. A theoretical analysis of the results has in turn yielded the distribution of radiation power density along the radiation propagation path, this distribution being determined by the power density of incident radiation and the ratio of ionization potential to photon energy. The author thanks B. G. Gorshkov, V. P. Kutakhov, V. M. Sidorin, and S. N. Stepanenko for many discussions. Figures 2; references 2: Russian.

UDC 07:12

**Phosphate Glass With High Neodymium Concentration as Picosecond Laser Tunable Over Wide Range of Wavelengths**

*18620200B Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 59 No 4, Apr 89 (manuscript received 11 Aug 87) pp 164-166*

[Article by P. V. Gorbunov, B. I. Denker, and D. G. Sarkisyan, Institute of General Physics, USSR Academy of Sciences, Moscow, and Institute of Physics Research, ArSSR Academy of Sciences]

[Abstract] A picosecond laser has been built, its active medium being phosphate glass with an Nd-ion concentration of  $8 \cdot 10^{20} \text{ cm}^{-3}$ , which emits ultrashort pulses of radiation tunable over the 1045-1079 nm range with correspondingly varying spectral width. The cavity is formed by two plane mirrors, a full-reflectance one and a half-reflectance one, on substrate wedges. Inside the cavity are an absorber cell adhering to the full-reflectance mirror with circulating 3274 or 3955 dye in nitrobenzene solution, one or two Fabry-Perot etalons for wavelength tuning and spectral width control, a telescope with x1.4 or x1.9 magnification depending on the absorber dye, a diaphragm, the active medium, and a Brewster glass plate. A slight misalignment of the telescope destabilizes the cavity so that the diaphragm can extract the lowest transverse mode with adequate stability. The active medium, a 50x100 mm<sup>2</sup> large glass

plate with high concentration of Nd ions, is pumped by an IFP-800 flash lamp. Both wavelength and spectral width of emission pulses are, after frequency doubling by a LiIO<sub>3</sub> crystal, recorded by a DFS-13 spectrograph and measured with a Fabry-Perot etalon. The time characteristics of a single light pulse, extracted by means of a Pockels shutter, are determined with the aid of a cross-correlator. Without a Fabry-Perot etalon this laser operates at the 1052 nm wavelength, emitting 5-6 ps pulses with an 8-10 cm<sup>-1</sup> spectral width. The threshold pumping energy is 25 J. Insertion of one Fabry-Perot etalon with a 0.010 mm wide slit facilitates tuning the laser radiation over the 1045-1079 nm range and widens the pulses to 30-40 ps while decreasing their spectral width to 1 cm<sup>-1</sup>. Insertion of two Fabry-Perot etalons with 0.030 mm wide and 0.400 mm wide slit respectively further widens the pulses to 200-250 ps while decreasing their spectral width to 0.15-0.2 cm<sup>-1</sup>. Figures 3; references 7: Russian.

**Coherent Amplification of Phase-Modulated Ultrashort Laser Pulses**

*18620205A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 4, Apr 89 (manuscript received 11 Jul 88) pp 1246-1255*

[Article by V. D. Taranukhin and S. Yu. Ten, Moscow State University imeni M.V. Lomonosov]

[Abstract] Coherent amplification of picosecond laser pulses phase-modulated with a linear chirp is analyzed for amplitude and frequency characteristics of the amplified pulses, without constraints on the length of time of transverse relaxation relative to the pulse duration. The system of equations describing such an amplification of such pulses with slowly varying amplitude and carrier frequency is solved first by the Riemann method for weak amplification in a two-level medium and then by the method of steady phase for any degree of amplification, taking into account the dispersive properties of the amplifying medium and including distortions caused by it. Numerical analysis pertains to a transverse-excitation high-pressure (10 atm) CO<sub>2</sub>-laser with constant nonzero inversion for amplification of picosecond radiation pulses. Their duration is varied over the 10-100 ps range and their chirp factor is varied from 0 to 46. Chirp is found to result in synchronous oscillatory modulation of the radiation intensity and instantaneous frequency along the pulse tail part, the original pulse form being restored without chirp upon amplification. Picosecond pulses with large chirp factor and modulation factor can thus be turned into terahertz pulse packets, the repetition rate within a packet being controllable by regulation of the chirp factor, while picosecond pulses with a chirp factor smaller than 4·pi can be efficiently compressed after amplification. Figures 4; references 26: 13 Russian, 13 Western.

**Measurement of Cross-Sections for Electrofission and of Photofission Yields Involving  $^{235}\text{U}$  and  $^{238}\text{U}$  Nuclei in 1.33-4.32 GeV Energy Range**

18620217A Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 5, May 89 (manuscript received 28 Jun 88)  
pp 1253-1256

[Article by Ye. A. Arakelyan, G. L. Bayatyan, N. K. Grigoryan, S. G. Knyazyan, A. T. Margaryan, and G. G. Marikyan, Yerevan Institute of Physics]

[Abstract] The cross-sections for electrofission and the photofission yields of  $^{235}\text{U}$  and  $^{238}\text{U}$  nuclei were measured at four levels of electron energy 1.33-2.26-3.33-4.32 GeV and maximum photon energy. The measurements were made with an electron beam extracted from the Yerevan Institute of Physics synchrotron and passed through a system: collimator - doublet lens - deflecting magnet - collimator - deflecting magnet - doublet lens. Uranium targets were affixed to the high-voltage electrode of a multiwire proportional chamber, this chamber serving as detector of fission fragments and filled with heptane vapor to a low pressure of 14 torr only. Measurements were made by a quantometer behind that chamber. For measurement of the photofission yield, the electron beam was diverted from its path to the chamber by turning on a third magnet and a continuous spectrum of bremsstrahlung photons was obtained on an aluminum radiator which had been placed in front of that magnet for this purpose only. Figures 5; tables 1; references 7: 5 Russian, 2 Western.

**Energy Spectra of Fragments Produced in Spontaneous Fission of  $^{242}\text{Cm}$  and in Fission of  $^{242\text{m}}\text{Am}$  by Fast Neutrons**

18620217B Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 5, May 89 (manuscript received 9 Aug 88)  
pp 1257-1260

[Article by E. F. Fomushkin, Yu. I. Vinogradov, V. V. Gavrilov, G. F. Povoselov, and A. M. Shvetsov]

[Abstract] An experiment involving both spontaneous fission of  $^{242}\text{Cm}$  nuclei and fission of  $^{242\text{m}}\text{Am}$  nuclei by neutrons with higher than 1.5 MeV energy was performed, its object being to measure and analyze the energy spectra of fission fragments in each case. A thin layer containing 0.010 mg (0.030-0.050 mg/cm<sup>2</sup>)  $^{242\text{m}}\text{Am}$  and also 0.000025 mg  $^{242}\text{Cm}$ , product of  $^{242\text{m}}\text{Am}$  decay, was in each case deposited on a 0.2 mm thick platinum substrate. No anomalies were detected in the spectra, relative to control spectra of fragments produced in spontaneous fission of  $^{252}\text{Cf}$ , in fission of  $^{235}\text{U}$  by thermal neutrons or by fast neutrons, and in fission of  $^{242\text{m}}\text{Am}$  by thermal neutrons. An analysis of the fine structure of the energy spectra and their statistically significant peaks, based on estimates of the energy as well as of mass number A and atomic number Z covering heavy and light primary fragments, reveals the same features characterizing the spectra of fragments

produced in "cold fission" of  $^{233}\text{U}$ ,  $^{235}\text{U}$ , and  $^{215}\text{Cm}$  by thermal neutrons. The estimates for light fragments indicate that most of them have an odd charge, one of the exception being the fragment whose atomic number is 38 and a low threshold for rupture of a proton pair being evidently responsible for this. Figures 1; tables 2; references 9: 7 Russian, 2 Western.

**Electron Emission During  $^{239}\text{Pu}$  Fission by Resonance Neutrons and Thermal Neutrons**

18620217C Moscow YADERNAYA FIZIKA in Russian  
Vol 49 No 5, May 89 (manuscript received 8 Jul 88)  
pp 1261-1265

[Article by G. A. Petrov, L. A. Popeko, and Yu. P. Rudnev, Leningrad Institute of Nuclear Physics, USSR Academy of Sciences]

[Abstract] Electron emission during  $^{239}\text{Pu}$  fission by resonance neutrons and thermal neutrons was measured, for a determination of the electron yield and the difference spectrum of emitted electrons. The experiment was performed in the horizontal channel of the VVR-M water-cooled water-moderated reactor at the Leningrad Institute of Nuclear Physics. A beam of thermal neutrons with an intensity of  $1.2 \cdot 10^7 \text{ n}/(\text{cm}^2 \cdot \text{s})$  was passed through a scattering chamber with the  $^{239}\text{Pu}$  target in the clearance between two segments of a superconducting solenoid and thus perpendicularly to the magnetic field. A sharp (100 meV wide) resonance at 0.29 eV was extracted by means of a Sm-filter. Electrons and fission fragments were recorded by surface-barrier Si(Li)-detectors, those for recording fission fragments being equipped with teflon collimators. All detectors were cooled with liquid nitrogen so as to ensure high energy resolution as well as high stability and high radiation resistance. The integral difference between the spectra of 140-1100 keV electrons, measured at a resonance point and at a thermal point, was found to be 0.00167-0.00183 electron per fission. The difference spectra of emitted electrons indicate a ( $n, \gamma & f$ )-reaction or fluctuational ionization of the atom shell, or both, but no changes in the mass yield of fragments during  $^{239}\text{Pu}$  fission by resonance neutrons and thermal neutrons. The authors thank V.F. Morozov, N.Ye. Mazurik, and L.R. Paat for building the detectors, V.G. Muratov and V.N. Muratova for programming the experiment, and I.V. Maninen for assisting in formulation of the results. Figures 2; references 18: 9 Russian, 1 Czechoslovak, 8 Western (1 in Russian translation).

**Hypersonic Solitons in Metals**

18620205B Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 4, Apr 89 (manuscript received 13 Sep 88) pp 1430-1443

[Article by A. Ye. Borovik, Ye. N. Bratus, and V. S. Shumeyko, Kharkov State University imeni A.M. Gorkiy]

[Abstract] Nonlinear evolution of a short longitudinal acoustic pulse in a metal is analyzed on the basis of the three-wave interaction model which follows from the theory of elasticity in the resonance approximation. The conditions for existence of soliton solutions to the corresponding system of exactly integrable equations having been established, the single-soliton solution is obtained by the method of the inverse scattering problem. It reveals the possibility of self-induced transparency and attendant soliton propagation without damping at a hypersonic speed. Both breather and two-soliton solutions are also obtained, the latter more easily with the aid of the McCall-Hahn factorizing ansatz. The authors thank A.V. Mikhaylov for discussing relevant aspects of the theory of integrable systems and for helpful comments, also V.P. Galayko, Ye.V. Bezuglov, and A.A. Slutskin for fruitful discussions of various problems. Figures 2; references 16: 12 Russian, 4 Western.

### Interaction of Resonance Spin-Flavor Precession and Resonance Oscillation of Neutrinos

*18620205C Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 4, Apr 89 (manuscript received 2 Sep 88) pp 1195-1207*

[Article by Ye. Kh. Akhmedov, Institute of Atomic Energy imeni I.V. Kurchatov]

[Abstract] Oscillation and spin-flavor precession of Majorana neutrinos in matter are analyzed together for interaction of their resonances, considering evolution of a neutrino system with only two flavors in a substance which has a constant density and is in a uniform transverse magnetic field. The equation of evolution is derived from the corresponding Hamiltonian in the flavor basis and then solved analytically for the case of overlapping, the case of nonoverlapping resonances also having been considered. Numerical data on the probabilities of oscillation and spin-flavor precession of solar neutrinos indicate that the two processes suppress each other when their resonances overlap but do more efficiently together than each alone convert an electron-left neutrino into a muon neutrino, because there are two conversion channels instead of one and overlap of the two resonances weakens the effect of nonadiabaticity near the sun. The author thanks Z.G. Berezhiani and A.Yu. Smirnov for helpful discussions. Figures 3; references 24: 13 Russian, 9 Western.

### Solitons in Loaded Atomic Chain With Cubic and Quartic Anharmonicity

*18620199A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 31 No 4, Apr 89 (manuscript received 1 Jul 88, in final version 22 Nov 88) pp 167-171*

[Article by R. Kh. Sabirov, Moscow State Pedagogical Institute imeni V. I. Lenin]

[Abstract] Propagation of nonlinear waves through atomic lattices under load, specifically through an atomic chain under tension, is analyzed for the effect of the loading force.

The atoms are assumed to interact with their nearest neighbors only and the interatomic potential energy is expanded into a Taylor series about the interatomic distance during equilibrium under zero external force. The problem is thus mathematically reduced to propagation of nonlinear waves through a free lattice, with the effect of loading indicated by the force dependent coefficients. A soliton solution is sought, assuming a positive coefficient of the quadratic second term. First only three terms are retained and thus only cubic anharmonicity is taken into account. Then also the fourth term is retained, assuming a positive coefficient, and thus quartic anharmonicity is taken into account as well. The solution is analyzed for the effect of an external tension force on the behavior of solitons, assuming also a positive coefficient of the cubic third term. References 15: 14 Russian, 1 Western.

### Atomic Probe With Compensation of Spread of Kinetic Ion Energy

*18620197B Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 7, 12 Apr 89 (manuscript received 1 Feb 89) pp 33-36*

[Article by A. N. Kudryavtsev, N. V. Nikonenko, B. M. Dubenskiy, and D. V. Shmikk]

[Abstract] A new atomic probe is described which combines the high space resolution of an autoionization microscope with the capabilities of a time-of-flight mass spectrometer, high resolution being attained by compensating the spread of kinetic ion energy. This spread is a consequence of premature volatilization of atoms off the surface of the needle emitter by high-voltage pulses in a strong electrostatic field, its effect in a conventional atomic probe being minimized by a toroidal deflector or a special lens. Such devices are inadequate in the case of large specimens or where the ratio of pulse-voltage amplitude to constant-voltage level needs to be large. A device which focuses ions in space and time while reflecting them in a uniform electrostatic field is proposed instead. It includes a micro-channel-plate multiplier with center hole which intensifies the autoionization image of the specimen surface, an oblique mirror and a microchannel-plate detector which pass desorbed ions through their center holes, and a double-gap reflector which throws ions back to the detector. Figures 2; references 7: 2 Russian, 5 Western (2 in Russian translation).

UDC 539.125.5:621.039.51

### Reflection and Transmission of Ultracold Neutrons by Two-Step Potential Barrier With Attendant Multiple Reflection

*18620195A Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA in Russian No 2 (147), Mar-Apr 89 (manuscript received 17 Nov 88) pp 48-53*

[Article by D. K. Kaipov and M. M. Kadykenov, Institute of Nuclear Physics, KaSSR Academy of Sciences, Alma-Ata]

[Abstract] Propagation of ultracold neutrons through a double-layer material is treated as a wave phenomenon involving reflection and transmission by a two-step potential barrier. It is accordingly described by the Schroedinger equation for three characteristic regions, the continuity condition for the wave function and its longitudinal gradient at both boundaries then yielding two pairs of algebraic equations for respective reflection and transmission coefficients. Taking into account multiple reflection and considering an obliquely incident neutron wave, these coefficients are calculated first for single-layer Al, SiO<sub>2</sub> (quartz glass), Cu, Dy, Au, Pb specimens and then for double-layer specimens consisting of an oxide or metal-coating surface layer on a homogeneous substrate: Al-Al<sub>2</sub>O<sub>3</sub>, Al-Au, SiO<sub>2</sub>-Dy, Cu-CuO, Dy-Dy<sub>2</sub>O<sub>3</sub>, Pb-Pb-O. Table 2; references 1: Western.

#### Formula for a Wilson Loop

18620165A Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY FIZIKI in Russian  
Vol 49 No 5, 10 Mar 88 pp 251-254

[Article by D. I. Dyakonov, V. Yu. Petrov]

[Abstract] This study derives a new formula for the contour-ordered exponent of a Yang-Mills field. For simplicity this analysis is limited to the non-Abelian group SU<sub>2</sub>. The analysis begins by considering the P-exponent along a given curve. The P-exponent is then expanded into a series in powers of the field and it is demonstrated that the desired formula for the P-exponent is a functional integral with respect to all gauge transforms of the field. A formula is derived where the Yang-Mills field occurs only in the exponent (without ordering) thereby substantially simplifying the averaging of the Wilson loop in the given ensemble of external fields. The entire dependence on the representation is

reduced to a common multiplier T in the exponent. Finally it is determined that the P-exponent by definition is the "spin" evolution operator in the time-dependent "magnetic field."

#### Calibration of Meteorite Olivine Crystals by <sup>238</sup>U Nuclei on the Bevalac Accelerator

18620165B Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY FIZIKI in Russian  
Vol 49 No 5, 10 Mar 88 pp 257-260

[Article by V. P. Perelygin, S. G. Stetsenko]

[Abstract] This study carries out an investigation of the primordial tracks from galactic cosmic nuclei in olivine crystals recovered from meteorites and carries out a sensitivity calibration by <sup>238</sup>U nuclei on the Bevalac accelerator. The crystals used in this study came from the Maryalakhti and Eagle station meteorites. The Olivine crystals were annealed at 430° plus or minus 1°C for 32 hours prior to etching in order to eliminate the background tracks of cosmic Fe. The first calibration experiment was performed on the Bevalac accelerator in November of 1987. The energy of the <sup>238</sup>U nuclei in this experiment was approximately 30 and 70 MeV per nucleon, the ion injection angle was 25° and was approximately 10° to the polished olivine crystal surface for a certain portion of the sample. The uranium ion fluence was approximately 10<sup>4</sup> nuclei per cm<sup>2</sup>. A comparison of the spectra of the accelerated <sup>238</sup>U tracks and the "primordial" tracks in these olivine crystals revealed that the group of "primordial" tracks approximately 210 mcm in length initially detected at the Joint Institute for Nuclear Research in 1980 were produced by Th-U galactic cosmic nuclei. The study claims that the new direction of research on galactic cosmic nuclei presented in the previous study (Z is greater than or equal to 50) based on meteorite crystal tracks is substantially more sensitive than other methods.

UDC 621.373.826

**Photoinduced Second-Harmonic Generation in Optical Fibers**

*18620208A Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 16 No 5, May 89 (manuscript received 26 Jan 89) pp 887-888*

[Article by Ye. M. Dianov, P. G. Kazanskiy, and D. Yu. Stepanov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] Considering that centrisymmetry of the amorphous glass structure precludes quadratic nonlinearity, a study of second-harmonic generation in an optical fiber after prolonged intense irradiation was made in search of an explanation. An experiment, the first of this kind, was performed with a 50 cm long optical fiber having a 0.009 mm diameter and a 0.12 numerical aperture, its core made of Ge-doped fused quartz and its sheath made of P-doped (3 pct  $P_2O_5$ ) fused quartz. In the recording mode 1060 nm radiation from a Q-switched YAG:Nd laser was pumped into the fiber in pulses of 50 ns duration and 1 kW power at a repetition rate of 10 Hz, while simultaneously 300 W of this radiation after being converted into 530 nm radiation by a LiNbO<sub>3</sub> frequency doubler with heating was entered into the fiber for priming. In the readout mode only 1060 nm radiation was pumped into the fiber, at room temperature, and second-harmonic radiation was found exiting from the fiber with an intensity which reached saturation level approximately one hour after recording had begun. The conversion efficiency in the fiber was 0.003 pct. Annealing the fiber at 300°C for 1 h prior to recording at room temperature did not significantly change the conversion efficiency but decreased the efficiency of second-harmonic generation, this decrease having been found to be reversible. On the basis of theoretical analysis, this phenomenon is interpreted in terms of departure from phase synchronism owing to temperature dependence of the refractive indexes. It can be utilized for nondestructively measuring the efficiency of second-harmonic generation as a function of the fiber length, namely by moving the heater along the fiber. Figures 1; references 10: 3 Russian, 7 Western.

UDC 535.41:778.38

**Stereoholograms With Monodisperse Speckle Reference Wave**

*18620208B Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 16 No 5, May 89 (manuscript received 28 Mar 88) pp 1060-1064*

[Article by A. M. Darskiy and V. B. Markov, Institute of Physics, UkrSSR Academy of Sciences, Kiev]

[Abstract] Three-dimensional phase holograms with a speckle reference wave are analyzed for displacement selectivity and its dependence on the speckle dimensions, assuming a small variance of the latter. For

experimental verification of theoretical relations, including the autocorrelation function of the speckle field in the plane of observation, is considered a scheme with a ring diaphragm behind the diffuser and the lens which form a subjective speckle pattern to serve as reference wave. The results obtained using diaphragms with different outside radii (2.5-10.0 mm) but the same width-to-radius ratio of 0.1 and a lens 20 mm in diameter with a focal length of 40 mm indicate that the displacement selectivity can be controlled by means of ring diaphragms, the speckle wave in the plane of observation having a narrower main peak and higher lateral peaks with a ring diaphragm than with a disk diaphragm of the same outside radius. Holograms with coded reference wave were recorded in LiNbO<sub>3</sub>:Fe crystals containing 0.01 wt.pct Fe by 441.6 nm radiation from a He-Cd laser according to the conventional two-beam scheme. The mean speckle dimension in a pattern formed by a circular radiating surface was found to be 1.25 times larger than the minimum possible one. The authors thank E.Kh. Gulanyan for valuable comments. Figures 2; references 5: 3 Russian, 2 Western.

**Fiber-Optic Fabry-Perot Interferometers With Single-Mode or Graded-Index Multimode Fibers**

*18620208C Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 16, No 5, May 89 (manuscript received 23 May 88) pp 1064-1067*

[Article by D. V. Baranov, I. V. Zhurilov, S. K. Isayev, L. S. Korniyenko, and A. A. Saliyev, Moscow State University imeni M. V. Lomonosov]

[Abstract] The feasibility of mass producing fiber-optic Fabry-Perot interferometers with single-mode or graded-index multimode fibers between two mirrors and of high-resolution high-speed spectrum scanning with such interferometers has been demonstrated on 15-20 cm long experimental low-loss (less than 10 dB/km) fiber specimens. The single-mode ones had a core 0.004 mm in diameter and their cutoff wavelength was 600 nm. The graded-index multimode ones carried a fundamental mode 0.010 mm in diameter at the 1/e<sup>max</sup> intensity level. The surface finish of the cut ends was inspected under a microscope, prior to deposition of multilayer dielectric mirrors with a transmission coefficient of 0.03-0.05 for 630 nm light. These interferometers were tested with a single-frequency He-Ne laser operating in the fundamental mode as light source, its radiation entering a fiber after passage through a focusing objective lens. A 10x attenuating filter before the fiber entrance shielded the laser from reflected light. Up to 70 pct of the laser beam power was transmitted by the fiber core. A diaphragm behind the fiber exit cut off parasitic light transmitted by the fiber sheath. Only one of the orthogonal linearly polarized fiber modes exiting from the fiber core was passed through a collimating objective-polarizer to a photodetector for measurements. The optical length of such an interferometer was modulated by means of a vibrator elongating a 5 cm long fiber segment stretched like a string. Spectrum scanning was

also done by heating or cooling the interferometer. Scanning a spectrum within a period as short as 0.030 ms was found to be attainable. The experimental data confirm fairly accurately theoretical predictions and indicate some advantages of these interferometers over conventional ones with polished slightly convex fiber ends, one of them being lower production cost. The authors thank Ye.M. Dianov for supplying the optical fibers. Figures 2; tables 1; references 10: Western (3 in Russian translation).

**Tunnel Microscopy of a  $\text{YBa}_2\text{Cu}_3\text{O}_7-\sigma$  Single-Crystal Facet at 4.2 K**

18620165C Moscow PISMA V ZHURNAL EKSPERIMENTALNOY FIZIKI in Russian Vol 49 No 5, 10 Mar 88 pp 268-270

[Article by S. L. Pryadkin, V. S. Tsoy]

[Abstract] This study makes it possible to obtain a stable, atomically-pure high-temperature superconductor surface by cleaving a single crystal at liquid nitrogen temperatures. A scanning tunnel microscope modified for low temperature operation is used to analyze the surface relief and I-V characteristic of a  $\text{YBa}_2\text{Cu}_3\text{O}_7-\sigma$  single crystal. The crystal specimens were 1 by 1 by 0.2 mm crystals. The C vector was perpendicular to the wafer plane. The superconducting transition temperature of the specimens was 90 K based on magnetic susceptibility measurements. Slow electron diffraction, Auger spectra and electron energy loss measurements carried out at room temperature in a high vacuum revealed that a substantial portion of the crystal surface was an atomically-pure face (001) producing an intense diffraction pattern. The study also produced scanning tunnel

microscopy images of the  $\text{YBa}_2\text{Cu}_3\text{O}_7-\sigma$  single crystal surface at 4.2 K and identified a dependence of  $\delta$  determined from the I-V characteristic on the width of the tunnel barrier for a certain fixed surface area. Possible causes of such a dependence include the proximity effect and the crystallographic anisotropy of  $\delta$ .

UDC 53.05

**Visual Demonstration of Phase Change Upon Passage of Wave Through Focus**

18620191A Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 32 No 3, Mar 89 (manuscript received 4 Feb 87) pp 104-105

[Article by V. V. Mayer, Glazov Institute of Education]

[Abstract] The apparatus built by V. A. Ostrovskiy for visual demonstration of phase change upon passage of a wave through a focus can be improved by replacing the planoconvex lens whose spherical surface has a large radius of curvature with a sinusoidal zone plate which splits a normally incident wave into three outgoing ones. Interference of two of them, the plane one and the one which converges at the real focus, reveals the phase of the converging wave before and behind the focus. The third wave, which diverges from the imaginary focus, is so weak that it does not significantly influence the demonstration. Besides the holographically produced zone plate, the apparatus will still include the Lg-78 He-Ne laser with a telescopic beam expander and a short-focus magnifying lens followed by a white screen. The author thanks Ye. S. Mamayeva for assistance. Figures 2; references 3: Russian.

UDC 539.89+539.226

**Kinetic Model of Electrical Polarization by Impact**

*18620224A Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 25, No 3, May-Jun 89  
(manuscript received 8 Dec 87, after completion  
10 Mar 88) pp 81-87*

[Article by S. I. Kubarev, G. A. Ponomarev, and A. I. Fokin, Ufa]

[Abstract] Kinetic theory is applied to electrical polarization by impact and a micromodel is constructed which takes into account thermal motion as well as finiteness of the temperature without prior stipulations about forces acting on a molecule. An array of globules with smooth surfaces is considered, their centers of mass being displaced from their geometrical centers along the path of a plane steady shock wave. The asymmetry of such molecules is assumed to be sufficiently small to make their translational motion and rotational motion mutually independent. Preliminary calculations in a system of space coordinates which moves together with the wavefront are followed by an analysis in Lagrangian coordinates. An expression is derived for the initial impact polarization proportional to  $\log(T^f/\sqrt{T^f_r/T^i_r})/T^f_r - T^i_r$  ( $T^f_r, T^i_r$  final and initial temperatures of rotational degrees of freedom) as well to the pressure behind the wavefront and to the compression ratio but inversely proportional to the shock wave velocity and to the molecule relaxation time. This model is used for estimating the initial polarization in real liquids such as nitrobenzene and in amorphous polymers, considering that any such polymer can be treated as a liquid of segments when the latter are sufficiently small for unconstrained motion but sufficiently large for motion independent of one another's. Tables 1; references 12: 7 Russian, 5 Western.

UDC 624.131+539.215

**Change in Detonation Waves Upon Freezing of Ground**

*18620224B Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 25 No 3, May-Jun 89  
(manuscript received 27 Jul 87) pp 96-102*

[Article by G. M. Lyakhov, I. A. Luchko, V. A. Plaksy, and N. S. Remez, Moscow and Kiev]

[Abstract] Propagation of a spherical detonation wave through frozen ground is analyzed, frozen ground having been found to behave as a nonlinear viscoplastic medium made up of three components around the free pore space filled with air: residual water, solid minerals, and ice. Each component, characterized by a density and a speed of sound, occupies a certain volume fraction. The problem is defined in the form of two partial differential equations of motion in Euler variables, supplemented with equations for ultimate static bulk compression ( $dp/dt$  approaching zero) and ultimate dynamic

bulk compression ( $dp/dt$  approaching infinity) of each component as well as the equation of bulk compression over a loading-unloading cycle and the equation of state for the detonation products in an isentropic process. This system of equations has been solved by numerical integration for a wave propagating through frozen loamy ground at -3 deg C upon detonation of a TNT (2,4,6-trinitrotoluene) charge. As a special case for comparison is considered unfrozen ground, such a ground also behaving as a nonlinear viscoplastic medium but consisting of only two components without ice around the free pore space. The results reveal differences between pressure transients and cavity expansion rate as well as between radial profiles of maximum stress, maximum strain, and particle velocity in frozen and unfrozen grounds. Figures 6; references 12: 9 Russian, 3 Western (1 in Russian translation).

UDC 534.222.2

**Decay of Plane Shock Waves Generated in Medium By Undercompressed Detonation of Explosive Charge**

*18620224C Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 25 No 3, May-Jun 89  
(manuscript received 9 Jul 87) pp 102-108*

[Article by A. V. Attetkov, M. M. Boyko, L. N. Vlasova, and V. S. Solovyev, Moscow]

[Abstract] Triggering an undercompressed and thus weak detonation of an explosive charge at its surface of contact with a condensed medium is considered, assuming plane shock waves generated as a result and thus a uniformly distributed load on the medium. Weak detonation is treated as a polytropic process and the equation of state for the gas of detonation products is formulated accordingly. Following a stipulation of the initial parameters and an analysis of the six characteristic flow regions, a region of steady flow existing in addition to five Chapman-Jouguet regions, the law of motion is obtained for shock waves in this medium with their trajectories defined in a Lagrangian system of coordinates. Its parametric representation in the quasi-isotropic approximation reveals the general trend of their decay. As the extreme case for comparison is considered "instantaneous" detonation in such a system. Figures 3; references 7: Russian.

UDC 532.23

**Development of Perturbations of Cylindrical Contact Surface Accelerated by Convergent Shock Wave**

*18620224D Novosibirsk FIZIKA GORENIYA I  
VZRYVA in Russian Vol 25, No 3, May-Jun 89  
(manuscript received 14 Sep 87, after completion  
5 Aug 88) pp 109-113*

[Article by A. I. Tolshmyakov and Ye. Ye. Meshkov, Moscow]

[Abstract] An experimental study of a convergent shock wave accelerating a cylindrical boundary between two different gases was made, of concern being attendant perturbations of that boundary and its stability characteristics. The apparatus was a rigid hollow cylinder containing a coaxial thin film of organic material between helium or Freon-12 on the inside and air on the outside. A cylindrical shock wave was generated by electrical breakdown of nichrome wires in the air space, 90 such wires 0.1 mm in diameter having been spaced uniformly around the separator film and connected in parallel across a 0.003 mF - 32 kV capacitor bank. Flow of the gases and motion of their boundary were tracked in space and time with a high-speed recording streak camera. The data are analyzed, taking into account pulsed acceleration of the boundary by the original shock wave and by the reflected one as well as its smoothly varying acceleration due to cylindrical convergence. Figures 5; references 6: 2 Russian, 4 Western (1 in Russian translation).

UDC 532.529

#### Structure of Shock Wave Propagating Through Two-Phase Medium

18620224E Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 25 No 3, May-Jun 89 (manuscript received 1 Sep 87, after completion 18 May 88) pp 115-117

[Article by K.N. Shamshev, A.M. Lapidus, V.N. Kulikov, and G.G. Tivanov, Moscow]

[Abstract] An experimental study of a shock wave propagating through a medium which consists of a carrier phase and a disperse was made, for the purpose of verifying and explaining the theoretically predicted formation of a rho-layer with higher particulate concentration behind the compression front. The apparatus included a vertical detonation chamber with an explosive charge on the bottom and a spray gun higher up, piezoelectric pressure transducers and optical radiation receivers having been installed along its cylindrical wall. An electromagnetic valve open during spraying prevented formation of an air cushion and thus ensured a uniform distribution of the disperse phase over the lower part of the chamber. The apparatus included also a laser or a quartz lamp sending a beam of light across the chamber through glass windows in it, the radiation transducers thus sensing this light as well as the intrinsic light emitted by the two-phase stream. Filters interchangeably placed in front of the quartz lamp served as spectral windows for narrow radiation bands covering the range from 150 nm ultraviolet to 3000 nm infrared. The results confirm the formation of a high-concentration rho-layer behind the compression front, as particles of the disperse phase initially moving at different velocities merge into a one-velocity body. Figures 2; references 4: Russian.

#### Nonlinear Waves in Electron Fluxes

18620190B Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 34 No 4, Apr 89 pp 565-566

[Article by A. M. Kalmykov and N. Ya. Kotsarenko]

[Abstract] This study analyzes nonlinear cyclotron waves appearing in electron fluxes in the presence of an external magnetic field. The cyclotron waves are found to decay into individual solitons whose parameters can be determined from a single-soliton solution to one derived equation within a specific frequency range. The study finds that solitons of cyclotron wave envelopes of the order of 1 cm in length can be excited in microwave electron fluxes which is of interest for high-power signal processing and transmission by means of electron beams.

#### Investigation of the Electrodynamic Properties of an Antenna for Excitation of Fast Magnetoacoustic Waves in a Tokamak

18620177A Moscow FIZIKA PLAZMY in Russian Vol 15 No 3, Mar 89 pp 279-287

[Article by A. V. Longinov and V. A. Tsurikov]

[Abstract] This study employs the "3-D" model to investigate the dependences of antenna impedances on plasma density for application to fast magnetoacoustic wave excitation in a tokamak for two types of systems: an antenna with a long-wavelength spectrum where the current density is assumed to be constant over the antenna surface and an antenna with a shortwave spectrum, which has a narrower spectrum with respect to the numbers of the longitudinal wave numbers. This system also analyzes the problems associated with the different excitation efficiency of asymmetric modes, specifically surface modes. The principal analysis focuses on fast magnetoacoustic wave excitation in an inhomogeneous plasma column for various modes based on an analysis of the partial RF energy fluxes radiated by the antenna for overlapping resonances and radiation in a half-space. The analysis revealed that using a model of an inhomogeneous plasma column surrounded by a conducting chamber to investigate fast magnetoacoustic wave excitation makes it possible to achieve a good approximation to the actual physical processes for investigating the impedance properties of the antenna systems. It was possible to enhance the ratio of the impedance to the reactance, i.e., to reduce the Q of the loaded antenna by increasing antenna size. A quasiresonance was found to exist in antennas with a broad spectrum in the resonance overlap mode; this quasiresonance corresponds to the excitation of modes with low longitudinal wave numbers.

UDC 548.3:539.26:666.233

**Crystalline Structure of Diamonds Produced By Detonation Synthesis**

*18620224F Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 25 No 3, May-Jun 89 (manuscript received 25 Jun 87, after completion 6 Oct 87) pp 126-129*

[Article by A.V. Kurdyumov, O.N. Breusov, V.N. Drobyshev, V.A. Melnikova, and V.F. Tatsiy, Chernogolovka]

[Abstract] A comprehensive structural study of diamonds produced by shock compression of graphite or soot and containing various amounts of lonsdaleite was made by the methods of x-ray diffraction analysis and transmission electron microscopy. Measurements were made in a DRON-2 x-ray diffractometer using monochromatized Co-radiation and with an RKU-114M photographic camera using filtered Cu-radiation. Clean diamond specimens were examined under a JEM-100SX scanning electron microscope. Based on the integral widths of 220 and 311 lines, diamonds produced from extrahigh-purity or colloidal graphite and containing lonsdaleite include larger coherent-scattering regions and, therefore, are more morphologically as well as substructurally nonhomogeneous than diamonds produced from soot. They are likely to retain traces of lamellar graphite. Figures 3; references 9: Russian.

**Formation of Cumulative Jets Upon Interaction of Shock Wave and Gas-Filled Soap Bubble**

*18620248B Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 10, 26 May 89 (manuscript received 6 Jun 88, in final version 10 Feb 89) pp 50-55*

[Article by E. M. Barkhudarov, M. O. Mdivnishvili, I. V. Sokolov, and M. I. Taktashvili]

[Abstract] An experiment was performed concerning interaction of a supersonic shock wave (Mach 1.1-1.2) and a spherical soap bubble containing helium, xenon, or air. The bubble was approximately 0.001 mm thick and approximately 3.5 cm in diameter. Shock waves were generated by a spark discharge with an energy of the order of 100 J, 4-6 cm away from the center of the bubble. Shadowgrams and photographs reveal formation of a "splash shroud," after passage of a shock wave, and its subsequent breakdown into a cumulative jet of droplets flowing behind the shock wave with an initial velocity of approximately 90 m/s when the bubble contained helium, 50 m/s when it contained air, and 33 m/s when it contained xenon. These estimates of the initial and also maximum jet velocity agree with theoretical ones based on the Rayleigh-Taylor kind of hydrodynamic instability and a flat bubble known to behave similarly, assuming that the acoustic shock wave has a plane front and carries a triangular pulse. The authors thank Tsintsadze for support, G. A. Askaryan and S. V. Bulanov for helpful discussion. Figures 2; references 9: 7 Russian, 2 Western.

**New Type of Mixed State With Positive Magnetization in High-Temperature Superconductors**

18620219A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 49 No 12, 25 Jun 89 (manuscript received 6 Mar 89, after revision 12 May 89) pp 664-668

[Article by E. G. Valiulin, A. A. Druzhinin, V. Ye. Startsev, and A. S. Shcherbakov, Institute of Metal Physics, Ural Department, USSR Academy of Sciences]

[Abstract] A new phenomenon occurring in high-temperature superconductors is reported, namely evolution of a state with positive magnetization in a constant external magnetic field. In an experiment with  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  ceramic and single crystals the force acting on them in a nonuniform magnetic field of a solenoid was measured over a 4-5 h long period. Measurements were made with a string magnetometer, without null drift and without movement of a specimens from its position, while stabilization of the current source energizing the solenoid and high inductance of the latter precluded any significant changes in the magnetic field. Tests were performed in the diamagnetic shielding mode with specimens cooled to 4.2 K prior to application of the magnetic field as well as in the Meissner mode with specimens cooled to 4.2 K in a constant magnetic field and then heated to above the critical temperature, the magnetic field being varied over the 0.1-4 T range. The magnetization was found to change with time in both modes, this trend and the temperature dependence of the magnetization not being related to hysteresis of the B-H curve. Analysis of the process according to the Ginzburg-Landau theory, aided by numerical solution of the corresponding equations, reveals formation of states in an isolated grain with dielectric boundary and in a developed structure with Josephson boundaries (twinning planes in single crystal). The modulus of the order parameter in these states has a maximum at a distance from the surface which corresponds to the square root of the flux quantum to external field intensity ratio. Another important factor influencing the evolution of magnetization into the positive range is interaction of phases in various grains owing to Josephson links. The authors thank V.L. Kozhevnikov for supplying the specimens, V.M. Dmitriyev and M.V. Sadovskiy for helpful discussion of the results. Figures 1; references 11: 4 Russian, 7 Western.

**Nelson-Kosterlitz Jump in  $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_x$  Single Crystals**

18620214A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 49 No 10, 23 May 89 (manuscript received 10 Apr 89) pp 566-569

[Article by S. N. Artemenko, I. G. Gorlova, and Yu. I. Latyshev, Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] An experimental study of the Kosterlitz-Touless transition in  $\text{Bi}-\text{Sr}-\text{Ca}-\text{Cu}-\text{O}$  single crystals with highly anisotropic electrical conductivity and a critical temperature about 80 K was made, this transition in  $\text{Y}-\text{Ba}-\text{Cu}-\text{O}$  ceramics being characterized by thermal generation of magnetic vortex pairs and a Nelson-Kosterlitz jump from linear to cubic current dependence of the voltage at the critical temperature. Single crystals of pure 2-2-1-2 phase in the form of wafers 1 mm square in the ab-plane and 0.001-0.015 mm thick along the c-axis were produced either by spontaneous crystallization from a slowly cooling molten mixture of  $\text{Bi}_2\text{O}_3$ ,  $\text{CaO}$ ,  $\text{SrCO}_3$ ,  $\text{CuO}$  with excess  $\text{CuO}$  or by crystallization from a molten solution of such a mixture in  $\text{KC}1$ . Measurement of the current-voltage characteristic at various temperatures by the standard method revealed a Nelson-Kosterlitz jump and an electrical conductivity 5.10<sup>4</sup> times higher in the ab-plane than along the c-axis at the critical temperature, the electrical resistivity in this direction having dropped to a residual 5 pct of its 0.2 mohm.cm magnitude at 300 K. The results are analyzed theoretically according to the two-dimensional model of superconductivity, for an evaluation of three-dimensional effects possibly impeding the Kosterlitz-Touless transition. Both magnetic and Josephson interactions are found to be negligible relative to the kinetic energy of superconduction so that thermal generation of vortices and their independent motion in different layers become possible, the Kosterlitz-Touless transition in quasi-two-dimensional  $\text{Bi}-\text{Sr}-\text{Ca}-\text{Cu}-\text{O}$  crystals thus being very similar to this transition in thin superconducting films. Figures 2; references 7: 3 Russian, 4 Western.

**Superhigh-Speed GaInAsSb P-I-N Photodiode for 1500-2300 NM Wavelengths**

18620197A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 7, 12 Apr 89 (manuscript received 7 Feb 89) pp 15-19

[Article by I. A. Andreyev, M. A. Afrailov, A. N. Baranov, S. G. Konnikov, M. A. Mirsagatov, M. P. Mikhaylova, O. V. Salata, V. B. Umanskiy, G. M. Filaretova, and Yu. P. Yakovlev, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of GaInAsSb p-i-n photodiodes for infrared fiber-optic communication lines was made, high speed being their most important characteristic. On a p-GaSb substrate with a hole concentration of  $2 \cdot 10^{17} \text{ cm}^{-3}$  was grown, by liquid-phase epitaxy, a 0.002 mm thick intrinsic GaInAsSb solid-solution structure with an electron concentration of  $4 \cdot 10^{13} \text{ cm}^{-3}$  and an energy gap of 0.53 eV. On this structure was then deposited a 0.003 mm thick n<sup>+</sup>-GaAlAsSb layer with an electron concentration of  $10^{18} \text{ cm}^{-3}$  and energy gap of 1.2 eV. The active GaInAsSb structure had become a p-type one with a hole concentration of  $4 \cdot 10^{14} \text{ cm}^{-3}$ . Photodiodes were produced by

the photolithographic process, in the form of meanders covering an area 0.090 mm in diameter, with Ag-coated Au:Zn and Au:Te electrodes deposited on the substrate and on the n<sup>+</sup>-GaAlAsSb window respectively. Their current-voltage and capacitance voltage characteristics as well as their sensitivity spectrum at room temperature were measured, for an overall performance evaluation. The response spectrum was recorded with an SPM-2 monochromator using an LiF prism, the results indicating maximum sensitivity within the 1500-2300 nm range of the spectrum. Response speed measurements were made using an REM-100U pulsed scanning electron microscope with a picosecond electron-beam modulator and also a computer(MERA 60)-controlled stroboscopic oscilloscope. The transit time can be estimated at 45-50 ps, which corresponds to a drift velocity of holes predominantly within the (5-6) × 10<sup>6</sup> cm/s in an electric field of approximately 20 kV/cm intensity. The photodiodes were tested in a 50-ohm strip line and with a reverse bias of 4 V. Figures 2; references 15: 7 Russian, 8 Western.

#### **Capture of Magnetic Flux by Tl-Ba-Ca-Cu-O Ceramic and Its Surface Resistance at High-to-Microwave Frequencies**

18620198B Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 5, 12 Mar 89 (manuscript received 18 Sep 88) pp 28-30

[Article by A. I. Akimov, M. M. Gaydukov, V. I. Gatalskaya, A. Karpyuk, L. Kovalevich, A. B. Kozyrev, La. A. Kurochkin, and Yu. N. Leonovich]

[Abstract] An experimental study of Tl<sub>1.4</sub>BaCaCu<sub>1.5</sub>O<sub>y</sub> ceramic with a 120 K critical superconducting transition temperature was made, one specimen having an electrical resistivity of 2 mohm·cm at room temperature. The other specimen, with an electrical resistivity of 0.6 mohm·cm at room temperature, contained a second phase with a lower superconducting transition temperature. A correlation was found to exist between the results magnetic inductance measurements and the temperature dependence of magnetic flux captured in a constant magnetic field of 11 G. The surface resistance of both specimens was measured by the resonator Q-factor method at two frequencies, 37 MHz and 60 MHz, at temperatures from 300 K down. Measurements of the captured magnetic flux and of the Meissner effect were made over the same temperature range. The results indicate that at the surface resistance of this ceramic remains constant at temperature above 120 K and below 70 K, which is evidently attributable to the state of intergranular boundaries in the material. Figures 2; references 2: Russian.

UDC 538.945

#### **Electronic Structure of High-Temperature Superconductors in Normal State**

18620213A Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 158 No 1, May 89 pp 155-161

[Article by I.I. Mazin, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] Two ways of describing the electronic structure of cupric high-temperature superconductors in the normal state are compared, one way according to the classical band theory combined with the Fermi-liquid model and one way according to the band theory combined with the Hubbard-Anderson model using the concept of localized electrons. Both ways are demonstrated on the La<sub>2-x</sub>Ba<sub>x</sub>CuO<sub>4-y</sub> group of such superconductors, whereupon new experimental evidence is cited which virtually invalidates application of the band theory to these materials. Most important is the semiconductor-like rather than metallic ground state of La<sub>2</sub>CuO<sub>4</sub> and YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6</sub>. Other evidence is antiferromagnetism of pure La<sub>2</sub>CuO<sub>4</sub> which vanishes fast upon replacement of some La by Ba or another alkaline-earth metal and appreciable orthorhombic distortion of the tetragonal structure at low temperatures in La<sub>2-x</sub>Ba<sub>x</sub>CuO<sub>4</sub> with x within the range of the magnetic phase. The evidence includes also results of photoelectron spectroscopy indicating an almost complete absence of d<sub>Cu</sub>-electrons and P<sub>O</sub>-electrons at the Fermi level, an about 1 eV higher than theoretically predicted location of the valence band, a frequency characteristic of the reflection coefficient without the theoretically predicted exciton absorption peak within the 0.3-0.6 eV range, and an about 20 pct lower than theoretically predicted plasma frequency. The author thanks D.A. Kirzhnits for the many helpful discussions. Figures 2; references 16: Western (1 in Russian translation).

#### **Structural Instability in Superconducting Amorphous Re-Ta-H System**

18620199B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 31 No 4, Apr 89 (manuscript received 18 Apr 88, in final version 20 Sep 88) pp 251-253

[Article by I. V. Zolotukhin, V. S. Zheleznyy, A. A. Lukin, A. M. Roshchupkin, and V. M. Fedorov, Voronezh Polytechnic Institute, Voronezh]

[Abstract] An experimental study of metallic glass (Re<sub>90</sub>Ta<sub>10</sub>)<sub>1-x</sub>H<sub>x</sub> was made, with the hydrogen concentration x varied over the 0-0.14 range electrolytically and thus under isothermal conditions. Film specimens were immediately after hydrogenation examined in a DRON-2.0 x-ray diffractometer with a two-crystal spectrometer using a MoK<sub>alpha</sub>-radiation source and a graphite monochromator. Their electrical resistivity, superconducting transition temperature, critical magnetic field near the critical temperature, and Young's modulus were determined on the basis of measurements. The mean distance between nearest neighboring atoms R<sub>c</sub> and the coordination number C were calculated from the shift of the first peak in the radial density distribution. Their Debye temperature, density of electronic states on the Fermi surface N(0), electron-phonon interaction constant, <<sup>2</sup>>, and Hopffeld parameter I<sup>2</sup> N(0) were also calculated. The results indicate that hydrogenation up to 0.04 does not significantly change the electron-phonon interaction constant but raises the critical superconducting transition temperature T<sub>c</sub> by approximately 3 pct. Such

a change can be explained only by an increase of the Debye temperature as hydrogen fills the free space and Young's modulus also increases. The subsequent lowering of the critical temperature  $T_c$  upon further hydrogenation is attributable to hydrogen-induced structural relaxation, which was found to cease at a 0.14 hydrogen concentration. Dipping of the electron-phonon interaction constant to a minimum and peaking of  $\Delta^2$  to a maximum at hydrogen concentrations of 0.10 and 0.12 respectively is interpreted on the basis of the "jelly" model and the Re-atom structure with seven valence electrons. Still to be explained remains the nontrivial concentration dependence of  $N(0)$ , but the available evidence already indicates that hydrogen stimulates formation of a new second amorphous phase of the  $Re_{90}Ta_{10}$  alloy. Figures 1; tables 1; references 12: 10 Russian, 2 Western (1 in Russian translation).

#### Low-Temperature Electrical Conductivity of Strongly Disordered Coulomb Systems

18620205D Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 4, Apr 89 (manuscript received 12 Apr 88, after revision 26 Aug 88) pp 1345-1354

[Article by A. L. Burin, Moscow Institute of Engineering Physics, and L. A. Maksimov, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] A new mechanism of electronic transitions other than Mott scattering responsible for electrical conductivity of strongly disordered systems such as doped semiconductors is considered, namely electron diffusion resulting in fluctuation of the one-particle-state energy within the Coulomb-gap range. This mechanism relies on electron-electron interaction and, hypothetically, remains operative when all electron-phonon interaction ceases. For theoretical analysis and experimental verification is considered an electronic system in a medium where the mobility threshold lies far above the Fermi level. Formation of electron pairs and resonance clusters is demonstrated, taking into account Coulomb repulsion but disregarding the role of spin. Low-temperature conductivity being of particular interest, this phononless diffusion mechanism is examined on the assumption that most electrons within the Coulomb-gap energy range near the Fermi surface participate in it causing irreversible gap-scale fluctuation of the Coulomb energy. The temperature dependence of the electrical conductivity is shown to follow the one-fourth power law and thus to be very weak within the lowest temperature range, owing to Coulomb interaction, but to gradually follow Mott's exponential law within higher temperature ranges characterized by increasing and possibly dominant role of electron-phonon interaction. The authors thank A.G. Aronov, S.V. Iordanskiy, N.V. Prokofyev, and D.Ye. Khmelnitskiy for interest and helpful discussions. Figures 1; references 17: 10 Russian, 7 Western.

#### Dependence of Electrical Resistivity of Bi-Sr-Ca-Cu-O Films on Conditions of Their Heat Treatment

18620248C Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 15 No 10, 26 May 89 (manuscript received 1 Mar 89) pp 4-7

[Article by Yu. A. Boykov, V. A. Danilov, Sh. M. Duguzhev, and T. B. Zhukova, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of 2212-phase Bi-Sr-Ca-Cu-O films was made, for the purpose of determining the dependence of their electrical conductivity on both temperature and duration of their heat treatment. Films 200-500 nm thick were produced by sputtering a 2212-phase compact target with a GOR-100M laser under a vacuum of  $10^{-6}$  torr and condensation on (100)MgO substrates at a temperature of 570-600 K. They were heat treated at various temperatures covering the 970-1170 K range for up to 2 h in air. The electrical resistivity of amorphous films, prior to heat treatment, was  $10^6$ - $10^7$  ohm.cm at room temperature. The electrical resistivity after heat treatment was measured over the 300-4.2 K temperature range. The lowest one at 300 K and at 100 K had films heat-treated at 1100-1110 K, their superconducting transition occurring within the 89.5-80.5 K range. The principal component of all heat-treated films was found to be the  $Bi_{2.15}(Sr_{1.68}Ca_{0.32})Ca_{1.17}Cu_2O_y$  Maeda phase, with inclusions of the  $Bi_2Sr_2CuO_6$  phase, its volume fraction decreasing and the temperature range of superconducting transition widening with lower heat-treatment temperature. Heat treatment at higher temperature produced also inclusions of the  $(Sr_{0.65}Ca_{0.35})CuO_3$  Wacy phase, Bi evidently having evaporated from the films. Shortening the duration of heat treatment to 30 min was found to appreciably decrease the volume fraction of inclusions. Figures 2; references 8: 3 Russian, 5 Western.

#### The Possibility for the Existence of Superconducting Correlations in Repulsive Fermi Systems

18620201B Kharkov FIZIKA NIZKIH TEMPERATUR in Russian Vol 15 No 5, May 89 pp 506-511

[Article by T. N. Antsygina and V. A. Slyusarev]

[Abstract] This article is devoted to an investigation of the possibility of explaining the phenomena of high-temperature superconductivity in metal-oxide compounds based on the Hubbard model using a more direct technique than has been attempted previously. Essentially this approach is a generalization of the approximation proposed by Hubbard. The analysis is based on a generalized self-consistent field technique. The physical picture proposed in the study is supported by an analysis of experimental data on the Hall effect in metal oxide

semiconductors published by Fukuyama and Hasegawa. No superconducting solution is found to exist when this method is used and double site occupancy is forbidden.

### A Second Sound Wave-Induced Magnetic Wave in Bismuth

*18620192C Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 49 No 8, 25 Apr 89 pp 443-445*

[Article by I. N. Zhilyaev]

[Abstract] This study considers the phenomenon whereby a diamagnetic wave is produced from the transmission of a thermal pulse through a bismuth specimen located in a longitudinal magnetic field at helium temperatures. Long bismuth parallelepiped specimens with a  $1 \text{ cm}^2$  cross-section and a length of 10 cm were used in the analysis. The thermal pulses were generated by means of a generator and a bifilar electrical heating fabricated from manganese wire .05 mm in diameter and glued to the face end of the specimen. The voltage pulse arriving in the coils was then amplified by an amplifier and displayed visually on an oscilloscope. The pulse generation effect is explained as follows. When the thermal pulse is injected to the specimen a second sound wave is generated, which then propagates along the specimen, producing an electrically neutral wave of charge carrier concentration in the electron-hole plasma. The study also assumes that phonon interaction with the boundaries causes the average surface velocity along the specimen to drop below the corresponding value in the bulk and therefore decompensation of the Larmor orbits will occur in the cross-section of the specimen which has an elevated charge carrier concentration near the boundaries.

### Microwave Investigation of Tl-Ba-Ca-Cu-O Ceramics

*18620196A Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIH NAUK in Russian No 2, Mar-Apr 89 pp 47-50*

[Article by B. B. Boyko, A. I. Akimov, S. V. Bogachev, V. I. Gatalskaya, S. Ye. Demyanov, V. A. Ilin, L. A. Kurochkin, Yu. N. Leontovich, and Ye. K. Stribuk]

[Abstract] This study investigates microwave absorption in a superconducting  $\text{Tl}_{1.4}\text{BaCaCu}_{1.5}\text{O}_y$  superconducting ceramic. The ceramic specimens were fabricated in a two-stage fabrication process by solid-phase synthesis. The ceramic specimens were analyzed in weak external constant fields. Results from both resistance and inductance measurements of the superconductivity of the specimens were in agreement with available data. Measurements of the weak-field microwave absorption of the Tl ceramic specimens below the critical temperature where d.c. resistance measurements cannot be used reveal certain interesting features in the temperature dependence of the absorption signal. Each such curve

has a sharp rise in the absorption signal amplitude as the temperature of the specimen approaches the critical temperature while a "plateau" appears after the temperature drops below the critical temperature, followed by a broadening of the low-field signal and a drop in its amplitude. Such features are due to the multiphase nature of the ceramics and irregularities in the granule size and intergranular distance.

### High-Temperature Superconductivity in the Dy-Ba-Cu-O System

*18620196B Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIH NAUK in Russian No 2, Mar-Apr 89 pp 50-54*

[Article by S. P. Tolochko, I. F. Kononyuk, A. V. Pogrebnyakov, F. F. Komarov, and A. A. Yelnitskaya]

[Abstract] This study examines the fabrication conditions, phase composition and electrical properties of Dy-Ba-Cu-O system specimens. The range of single-phase orthorhombic  $\text{Ba}_{1-x}\text{Dy}_x\text{CuO}_{3.8}$  solid solutions in the range .30 is less than or equal to x is less than or equal to .35 is identified where a sharp transition to the superconducting state occurs between 92 and 94 K. Upon heating above 650 to 700 K the  $\text{DyBa}_2\text{Cu}_3\text{O}_{7-\delta}$  compound becomes unstable, loses oxygen and converts into a tetragonal structure. A new  $\text{DyBa}_3\text{Cu}_2\text{O}_x$  compound is obtained; this compound appears to be similar in structure to the oxygen-deficient perovskite structure  $\text{BaDy}_{0.33}\text{Cu}_{0.67}\text{O}_{3.8}$ .

### The Features of Nuclear Relaxation in a Superconductor With Strong Interelectron Correlations

*18620192A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 49 No 8, 25 Apr 89 pp 437-439*

[Article by Yu. V. Kopayev and L. R. Tagirov]

[Abstract] This study demonstrates that in the case of a high potential electron repulsion energy for the case of opposite spins at a single site the coherence factor in the relaxation rate will be near unity and the temperature dependence of the resistivity will diminish monotonically below the superconducting transition temperature. The study also demonstrates that the rate of nuclear magnetic relaxation in the superconducting phase becomes a monotonic function of temperature, unlike the prediction of BCS theory.

### The Properties of Lattices With "Large" Josephson Junctions Between Superconducting Granules

*18620192B Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 49 No 8, 25 Apr 89 pp 440-443*

[Article by V. V. Bryksin, A. V. Goltsyev, and S. N. Dorogovtsev]

[Abstract] This study presents results from an investigation of a Josephson junction lattice for the case where the granules have linear dimensions greater than the London length. The study also derives formulae for determining the temperature dependences of the electrical and magnetic field strengths for the case of a Josephson junction with a dielectric interlayer. The analysis also determines the Penning energy of the vortices for the same case where the linear dimensions of the superconducting granules exceed the London length. The equation system derived in this study accounts for the intrinsic field effect of the Josephson currents at the same time that the field and the coupling force between the granules within the framework of the ordinary XY model are assumed to be given. This approach can also be easily generalized to other types of lattices as well as disordered systems.

**The Effect of Dissipation on the Dynamical Characteristics of Small Tunnel Junctions Within the Framework of the Polaron Model**

18620201A Kharkov FIZIKA NIZKHIKH TEMPERATUR in Russian  
Vol 15 No 5, May 89 pp 466-473

[Article by A. A. Odintsov]

[Abstract] This study is devoted to an investigation of the response of a compact tunnel junction to weak and strong harmonic action within the framework of the polaron model. This analysis employs a kinetic equation to calculate the impedance and the I-V characteristic of the tunnel junction for the case where the junction is exposed to a harmonic microwave signal. Increasing temperature is found to enhance the noncoherent absorption processes, particularly in the low frequency range. Other changes in tunnel junction behavior induced by variations in temperature are discussed. The study provides a family of I-V characteristics for various alternating signal intensities for the case where the tunnel junction is exposed to a strong microwave harmonic signal.

**The Energy Gap of BiSrCaCuO High-Temperature Superconductors**

18620201C Kharkov FIZIKA NIZKHIKH TEMPERATUR in Russian  
Vol 15 No 5, May 89 pp 518-520

[Article by V. M. Dmitriev, A. L. Solovyev, A. I. Dmitrenko, L. A. Ishchenko, and L. A. Kotok]

[Abstract] This study is devoted to an investigation of the I-V characteristics and their first derivatives for point contacts between niobium and the  $\text{Bi}_2\text{S}_{2.33}\text{Ca}_{0.67}\text{Cu}_2\text{O}_x$  high-temperature superconducting ceramic between 4.2 K and the superconducting transition temperature of the contacts. These specimens were fabricated as tablets 14 mm in diameter and 3 mm in thickness. The irregular features of the I-V characteristics and their derivatives were observed only on the

ceramic contacts having a clearly-expressed metallic progression of the resistance versus temperature relation measured by the ordinary four-probe technique. A drop in the resistance with an increasing bias voltage above  $\delta/E$  characteristic of high-temperature superconductors was also observed. Such features could, however, also be due to the development of nonequilibrium processes in the contact. The preliminary results given here suggest that the magnitude and temperature dependence of the BiSrCaCuO high-temperature superconducting ceramics follow BCS theory in the strong coupling limit.

**Observation of the Josephson Effect in TlBaCaCuO-TlBaCaCuO Junctions**

18620201D Kharkov FIZIKA NIZKHIKH TEMPERATUR in Russian  
Vol 15 No 5, May 89 pp 535-536

[Article by A. I. Akimov, B. B. Boyko, S. I. Borovitskiy, V. I. Gatalskaya, V. D. Gelikonova, S. Ye. Demyanov, A. M. Klushin, L. A. Kurochkin, and Ye. K. Stribuk]

[Abstract] This study analyzes thallium ceramic Josephson junctions exposed to a microwave field at temperatures between 78 and 102 K. The Josephson junctions were fabricated by slicing 7 by 1.5 by 1.5 mm<sup>3</sup> thallium ceramics to achieve a critical temperature of 1-3 mA in liquid nitrogen. The I-V characteristics of the specimens were measured by a four-probe technique at temperatures exceeding 78 K. The study provides a family of I-V characteristics obtained at various microwave irradiation power levels at a frequency of 9.46 GHz and a temperature of 98 K. Studies of the temperature dependence of the critical current of the specimen indicated that the critical current was .087 mA in the 102-78 K range. At liquid nitrogen temperatures the critical frequency of the junction was 73 GHz with a critical current of 2.35 mA and a normal junction resistance of .075 ohms.

**Static Fluxon States in A Weak-Link System of Josephson Junctions With a Microinhomogeneity**

18620184A TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian  
Vol 77 No 3, Dec 88 pp 333-339

[Article by N. M. Atakishiev and M. S. Pomerants]

[Abstract] This study analyzes a system of two identical semi-infinite weak-link SIS Josephson junctions in an external magnetic field with one of the junctions containing an inhomogeneity: a local area of higher junction resistance. A piecewise-linear model is used to carry out a comprehensive quantitative analysis of the statistical states of the flux in Josephson junctions. This model yields analytical solutions in elementary functions, thereby substantially simplifying the analysis of the static solution. The study also carries out a comprehensive analysis of the static states in superconducting Josephson junctions with a single microinhomogeneity

and demonstrates the parameters of the problem including the inhomogeneity coordinates and the coupling constants have an effect on the magnetic field distribution in the superconducting Josephson junctions. A stable static state is found to exist in the superconducting Josephson junctions, as in the case of a single junction. The critical field magnitude at which a fluxon forms in a weak link superconducting Josephson junction is discovered to be substantially lower than for a single isolated Josephson junction.

### The $\epsilon$ to $\delta$ Phase Transition in the $TiH_{0.71}$ Hydride: Superconductivity and Electrical Resistance

18620181D Leningrad FIZIKA TVERDOGO TELA in Russian Vol 31 No 2, Feb 89 pp 91-96

[Article by V. M. Teplinskiy, I. O. Bashkin, V. Yu. Malyshev, and Ye. G. Ponyatovskiy]

[Abstract] This study investigates the behavior of the electrical resistance and the characteristics of superconductivity in a  $TiH_{0.71}$  hydride for the case of heating to room temperature, where the epsilon-phase makes an irreversible transmission to the delta-phase which is nonsuperconducting to a temperature of greater than or equal to 2 K. A series of low-temperature annealings were used to investigate different intermediate states in this irreversible transmission process. The .3 by .6 by .6 mm polycrystalline  $-TiH_{0.71}$  specimens were fabricated by quenching at a pressure of approximately 60 kbar. The specimens cooled to liquid nitrogen temperatures without heating were placed in a helium cryostat whose temperature was varied from approximately 1.2 K to room temperature. The resistance of the specimens were measured by using a four-contact a.c. probe (frequency 34 Hz) and the resistivity was then calculated. This series of annealings was used to both identify the various intermediate states and to carry out measurements for each such state. The characteristic dependence of the superconducting transition temperature on the resistivity suggests several stages in the transformation process. In the temperature range where all processes involved in the irreversible changes are frozen, the resistivity relation is accurately approximated by the functions  $AT^2$  plus  $BT^3$ . The study also reports the behavior of the coefficients A and B during the irreversible structural changes occurring in the specimen.

UDC 669.725.5:537.312.62

### Superconductivity of $Ni_4Be_{22}$ $\gamma$ -Phase

18620236A Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 34 No 7, Jul 89 (manuscript received 25 May 88) pp 1103-1105

[Article by N. N. Matyushenko, A. A. Matsakova, and N. S. Pugachev, Institute of Engineering Physics, UkrSSR Academy of Sciences, Kharkov]

[Abstract] An experimental study of  $Ni_{4-x}Be_{22+x}$   $\gamma$ -phase brass was made, this phase but not the  $\beta$ -phase having been found to be a superconductor material. Specimens with 13 percent Ni ( $Ni_{3.38}Be_{22.62}$  and specimens with 18 percent Ni ( $Ni_{4.68}Be_{21.32}$   $\gamma$ -phase) had been produced by diffusion of 99.95 percent pure Be-condensate into 99.99 percent pure Ni-foil, inside a container made of BeO, at 1150 deg C under vacuum. They were examined in a DRON-2.0 x-ray diffracto-meter with a  $CuK_\alpha$ -radiation source at temperatures down to liquid helium. The results of x-ray phase analysis, metallographic analysis, and electrical resistance measurements indicate that the  $\gamma$ -phase begins to become superconducting at 2.05 K and confirm that the  $\gamma$ -phase ( $Ni_{5-x}Be_{21+x}$ ) becomes so at 0.78-0.72 K. Figures 1; references 10: 3 Russian, 7 Western.

UDC 537.622

### Temperature Dependence of Upper Critical Magnetic Field for Amorphous Bismuth Films

18620246A Kiev FIZIKA NIZKIKH TEMPERATUR in Russian Vol 15 No 4, Apr 89 (manuscript received 11 Mar 88) pp 397-405

[Article by B. I. Belevtsev and A. V. Fomin, Institute of Low-Temperature Engineering Physics, UkrSSR Academy of Sciences, Kharkov]

[Abstract] An experimental study of ultrathin high-resistivity amorphous Bifilms was made, for the purpose of determining the temperature dependence of the upper critical magnetic field  $H_{c2}(T)$  for such films. Films not thicker than 10 nm were deposited on slices of a sapphire single crystal in a cryostat at a 1.5-2.0 K temperature under a residual pressure not exceeding 5 multiplied by  $10^{-9}$  torr. They were annealed at a temperature within 25-30 K, within the range of existence of the amorphous phase. First was then measured their normal electrical resistance  $R_N$  in a magnetic field of approximately 48 kOe perpendicular to their plane. The temperature dependence of their electrical resistance  $R(T)$  was measured in such a magnetic field at various constant levels of its intensity, the critical temperature  $T_c$  having been found to range from 5.42 K for 9 nm thick films with a surface resistance of 0.2 kohm to 3.57 K for 1.5 nm thick films with a surface resistance of 4.4 kohms. The field dependence of their electrical resistance  $R(H)$  was measured at various constant temperatures, the upper critical magnetic field  $H_{c2}$  being defined as its intensity at which the electrical resistance of a film had dropped to  $1/2R_N$ . The temperature dependence of the upper critical magnetic field  $H_{c2}(T)$  over the (0.1-1.0) $T_c$  range was determined from the sets of  $R(T)$  and  $R(H)$  curves, all those curves being quite steep within the superconducting transition range with the Aslamazov-Larkin correction for fluctuation included and the resulting  $H_{c2}(T)$  curves being convex. The data, nondimensionalized to  $h_{c2}(t)$  where  $t$  denotes the ratio  $T/T_c$  and  $h_{c2}$  denotes the quotient  $H_{c2}/(-dH_{c2}/dt)T_c$  are analyzed from the standpoint of the Werthamer-Helfand-Hohenberg theory in

the Ginzburg-Landau approximation for dirty superconductors. Their deviation from it is found to increase with increasing surface resistance, a measure of disorder in a film. The results reveal that the slope  $dH_{c2}(T)/dT$  of the  $H_{c2}(T)$  curves becomes steeper, up to minus infinity at  $T_c$ , as the surface resistance of a film becomes much higher than 1 kohm but remains negative without a linear range at temperatures below  $T_c$ . The convexity of the  $H_{c2}(T)$  curves, characteristic of superconductors with strong electron-phonon interaction, reflect the competition between electron localization and superconductivity, this competition determining the degree of disorder and influencing the shift of the critical temperature. Figures 3; references 30: 8 Russian, 22 Western (1 in Russian translation).

UDC 538.945

### Band Structure of Metal-Oxide Superconductors

18620245A Kiev FIZIKA NIZKIKH TEMPERATUR in Russian Vol 15 No 3, Mar 89 (manuscript received 16 Feb 88) pp 265-270

[Article by T. N. Antsygina and V. A. Slyusarev, Institute of Low-Temperature Engineering Physics, UkrSSR Academy of Sciences, Kharkov]

[Abstract] The electronic energy spectrum of metal-oxide high-temperature superconductors is analyzed on the basis of a two-band model which differs from the Bardeen-Cooper-Schrieffer model and derives from their crystal structure, the latter being characterized by a layerwise arrangement of square plane O-Cu-O lattices. This two-dimensional model, high-temperature superconductivity being regarded as an essentially two-dimensional phenomenon, is described with a Hamiltonian which yields a system of two coupled equations for the two order parameters Delta and D. Interband interaction is considered in the approximation of a self-consistent field, interaction within the narrow band is also included, and interaction within the wide band is ignored. An equation for the critical temperature is obtained for this case, such a temperature always existing when the electron-electron interaction is negative and when it is positive but below some critical value. A negative interaction constant corresponds to absence of significant Pauli paramagnetism. A positive one corresponds to ferromagnetic ordering in the model, even though that system of equations has no superconductivity solutions. The authors thank L. A. Pastur for interest and fruitful discussions. Figures 2; references 15: 6 Russian, 9 Western (2 in Russian translation).

### Intraband Tunneling Transfer of Quasimomentum

18620240C Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 96 No 1, Jul 89 (manuscript received 20 Dec 88) pp 246-252

[Article by B. I. Ivlev and Yu. N. Ovchinnikov, Institute of Theoretical Physics imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] Motion of a particle in a periodic potential in a dissipative medium is considered, this problem relating to the dynamics of low-capacitance Josephson junctions and to nonadiabatic electron-electron interaction in crystals. The potential is, in the one-band approximation, assumed to be a cosine function of the particle quasimomentum as coordinate. An analysis of the statistical particle-medium sum Z reveals that it corresponds to the statistical sum of a massless particle and a thermostat strongly interacting with one another, which leads to an analogy to a massless particle attached to an elastic string. The probability of interband tunneling transfer of quasimomentum is, accordingly, calculated on the basis of the Lagrangian of this analogous system. Such a quasimomentum transfer contributes to relaxation of the particle distribution in a band and, in the case of an infinitely high shunting resistance (absence of "Gaussian" dissipation), tunneling of the quasimomentum remains the only cause of damping of one-frequency vibrations in a Josephson junction. A quasimomentum close to the boundary of the Brillouin zone and motion of a particle in a linearly sloping periodic potential are considered as cases of special interest. Figures 1; references 12: 6 Russian, 6 Western.

### Anisotropy of Optical Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$ and Bi-Sr-Ca-Cu-O Superconductor Crystals

18620235C Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 50 No 1, 10 Jul 89 (manuscript received 26 May 89) pp 25-29

[Article by M. P.. Petrov, A. I. Grachev, M. V. Krasinkova, A. A. Nechitaylov, V. V. Poborchiy, S. I. Shagin, and S. V. Miridonov, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences]

[Abstract] Reflection spectra of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  (d slightly larger than 0.1) and Bi-Sr-Ca-Cu-O lamellar (ab)-plane superconductor crystals were recorded under an electron microscope in visible and near-infrared light over the 0.7-3.0 eV range and with a Fourier-spectrometer in intermediate-infrared light over the 0.5-0.7 eV range past the 0.28 eV absorption peak. All crystals were 0.005 mm thick along the c-axis and had each a large twinless single-domain region in the(ab)-plane. The critical superconducting transition temperature was about 90 K for the  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  crystals and about 82 K for the Bi-Sr-Ca-Cu-O crystals. The spectra, polarized with the electric field vector parallel to the a-axis and with the electric field vector parallel to the b-axis, were processed according to Kramers-Kronig relations. They were also processed by fitting a given model frequency dependence of the dielectric permittivity by the method of the least squares. The results reveal an anisotropy of the reflection coefficient R and its dispersion with a large difference  $R_b - R_a$  for  $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$  crystals, especially in infrared light, and a very small difference  $R_b - R_a$  for Bi-Sr-Ca-Cu-O crystals also within that range. Fitting the permittivity model has yielded the plasma frequency, the

charge-carrier relaxation frequency, and the high-frequency permittivity. Figures 3; references 9: 2 Russian, 7 Western.

### **Structure of $TlBa_2(Ca_{0.87}Tl_{0.13})Cu_2O_7$ Superconducting Single Crystals With Critical Temperature About 80 K**

18620235D Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 20 No 1, 10 Jul 89 (manuscript received 7 Apr 89) pp 40-43

[Article by N. N. Kolesnikov, V. Ye. Korotkov, M. P. Kulakov, G. A. Lagvenov, V. N. Molchanov, L. A. Muradyan, V. I. Simonov, R. A. Tamazyan, R. P. Shibayeva, and I. F. Shchegolev, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] An experimental study of  $TlBa_2CaCu_2O_7$  1212-phase single crystals was made concerning their structure and superconductivity. Such crystals were produced from a mixture of  $Tl_2O_3$ , BaO, CaO, CuO powders by slow cooling of the  $TlBa_2CaCu_2O_x$  melt in alundum capsules in an oxygen stream, at rates of 5 deg/h from 1250 K to 1050 K, 150 deg/h from 1050 K to 700 K, and 250 deg/h from 700 K to 300 K. One large specimen with lattice parameters corresponding to pure 1212 phase was selected for analysis. The superconducting transition was found to begin at about 80 K, according to the temperature dependence of both magnetic moment and diamagnetic shielding in a magnetic field of 10 Oe measured with a high-frequency SQUID magnetometer. Structural examination in an RED-4K automatic x-ray diffractometer with a  $MoK_\alpha$ -radiation source and a graphite monochromator, done by omega and omega/theta scanning at a variable speed, has yielded not only the coordinates of atoms and the interatomic distances but also the thermal parameters of atoms including  $B_{equiv}$  and the a,b,c, semiaxes of thermal vibration ellipsoids. The precise composition of this 1212 phase is, on the basis of these data,  $TlBa_2(Ca_{0.87}Tl_{0.13})Cu_2O_7$ . Its crystal structure evidently consists of Ba, Ca, Cu coordination polyhedra configured similarly but not quite as in a  $YBa_2Cu_3O_7$  crystal and a strongly distorted Tl coordination octahedron. The authors thank P. A. Kononovich for assistance and for discussing the results. Figures 2; tables 2; references 13: Western.

### **Raman Scattering by Electrons and Superconduction Gap in $Tl_2Ba_2CaCu_2O_8$ Single Crystals**

18620235E Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 50 No 1, 10 Jul 89 (manuscript received 8 Apr 89) pp 44-46

[Article by A. A. Maksimov, I. I. Tartakovskiy, and V. B. Timifeyev, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] An experimental study of  $Tl_2Ba_2CaCu_2O_8$  single crystals (critical superconducting transition temperature 110 K) was made which involved measurement of Raman scattering by electrons and determination of its temperature dependence. The (ab)-base of such a crystal was excited by 488 nm light from an  $Ar^+$ -laser with a slightly lower than 15 mW incident power. Spectra covering the 40-800  $cm^{-1}$  frequency range were recorded with a "Dilor XY" spectrometer, in an optical helium thermostat with He-vapor for temperature regulation over the 5-300 K range accurately within 0.05 K. The spectra reveal that the scattering intensity at frequencies above 400  $cm^{-1}$  remains almost constant and at a frequency of 400  $cm^{-1}$  or slightly below increases as the temperature is raised from 4.2 K toward the critical, a drop of scattering intensity at frequencies far below 400  $cm^{-1}$  occurring which vanishes as the temperature approaches the critical. These trends indicate existence of a superconducting gap, twice its maximum magnitude being estimated at  $5k_B T_c$  but not sufficient data being available for estimation of its minimum magnitude. Normal regions evidently still existing in a crystal prevented Raman scattering by electrons at any frequency within the entire range from ceasing altogether even at 4.2 K. The authors thank L. A. Falkovskiy for helpful discussion. Figures 2; references 10: 6 Russian, 4 Western.

UDC 537.311.33

### **Bi-Sr-Ca-Cu-O Films Produced by Laser Sputtering**

18620209B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 31 No 5, May 89 (manuscript received 22 Nov 88) pp 282-285

[Article by Yu.A. Boykov, M.P. Volkov, V.A. Danilov, B.T. Melekh, and Yu.N. Filin, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Thin Bi-Sr-Ca-Cu-O films were experimentally deposited on (100) slices of MgO single crystals and on BeO ceramic substrates by sputtering with a GOR-100M ruby laser (694 nm wavelength) under a vacuum of  $1 \cdot 10^{-6}$  torr, two kinds of targets having prepared for this from mixtures of extrahigh-purity  $Bi_2O_3$ ,  $SrCO_3$ ,  $CaCO_3$ , CuO in ratios 2:1:1:2 and 1:2:1:2 respectively. The laser power was varied over the  $10^5$ - $10^7$   $W/cm^2$  range, the duration of laser pulses was 1 ms. The temperature of the substrates during condensation was varied from 620 K up, the films growing much slower and becoming depleted of Bi as the temperature of the substrates was raised above 770 K. A laser power of  $10^7$   $W/cm^2$  was found to convert targets into microdrops up to 50 nm in diameter. Targets of the 2:2:1:2 mix were found to yield, after heat treatment of the condensate,  $Bi_{2-x}Sr_{2-x}CaCu_{1.9}O_x$  films when sputtered with a laser power of  $10^7$   $W/cm^2$  and  $Bi_{1.2}Sr_2CaCu_{1.9}O_x$  films when sputtered with a laser power of  $10^5$   $W/cm^2$ . Fresh films were amorphous with a high electrical resistivity

throughout the entire temperature range down to 4.2 K. Heat treatment resulted in their recrystallization and saturation with oxygen, grains formed on MgO single crystals being 2-3 times larger than those formed on BeO ceramic. The electrical resistivity dropped by six orders of magnitude within the 90-80 K temperature range after heat treatment at 970 K, heat treatment at higher temperatures up to 1070 K resulting in a larger drop but over a wider temperature range and heat treatment at still higher temperature (1090 K) shifting the superconducting transition to below 63 K. Figures 2; references 6: 1 Russian, 5 Western.

### Motion of Abrikosov Vortices in Anisotropic Superconductors

18620216A Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 6, Jun 89 (manuscript received 16 Jan 89) pp 2170-2174

[Article by V.M. Genkin and A.S. Melnikov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] The motion of Abrikosov vortices in an anisotropic superconductor carrying a transport current is described according to the Ginzburg-Landau theory, taking into account the action of Lorentz forces on the vortex line and the effect of drag which appears in the absence of pinning. Energy dissipation is in this case associated with flow of normal currents and appearance of an electric field as well as with relaxation of the order parameter. Anisotropy is shown to influence both ohmic and relaxation losses, but differently each, a vortex moving obliquely rather than perpendicularly to the direction of current flow. The electric field is also shown not to be perpendicular to the direction of current flow, which indicates existence of a Hall field even when the magnetic field is perpendicular to the direction of current flow. The drag in the case of viscous flow depends, moreover, strongly on the orientation of the Abrikosov vortices relative to the axis of anisotropy. Analysis of this phenomenon applies particularly to high-temperature type-II superconductors such as  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ , which are characterized by a strong anisotropy of properties in both normal and superconducting states. Figures 1; references 4: 3 Russian, 1 Western.

### Possibility of Magnetic Field Inducing Superconductivity in Metal With Kondo Impurities

18620216B Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 6, Jun 89 (manuscript received 27 Jan 89) pp 2235-2247

[Article by A.N. Podmarkov and I.S. Sandalov, Institute of Physics imeni L.V. Kirenskiy, Siberian Department, USSR Academy of Sciences]

[Abstract] Experiments having revealed that an external magnetic field can induce superconductivity in a material such as  $\text{Sn}_{0.25}\text{Eu}_{0.75}\text{Mo}_6\text{S}_{7.2}\text{Se}_{0.8}$ , a superconductor metal with small coherence length and weak links containing normal and magnetic impurities is considered in an external magnetic field for a theoretical resolution of this paradox. Its phase diagrams in the  $T$ - $H$ - $c_m$  domain are constructed for establishment of the limits of its superconductivity with respect to temperature  $T$ , magnetic field intensity  $H$ , and magnetic impurity concentration  $c_m$ . The diagrams are constructed on the basis of equations for the order parameter and the superconducting transition temperature in accordance with the Abrikosov-Gorkov theory covering the temperature range between the Kondo temperature and the critical temperature for pure metal. They demonstrate that an external magnetic field can induce superconductivity in an impure metal under conditions corresponding to  $s$ (impurity spin)- $f$ (conduction electron) exchange interaction with a negative nonzero exchange constant and thus with the Jaccarino-Peter effect. They also indicate that Kondo scattering of conduction electrons by magnetic impurity levels appreciably raises the limiting concentration of magnetic impurity above which superconductivity below the critical temperature, depending on the magnetic field intensity, vanishes but at the same time wipes out the range of return to superconductivity and thus all nontrivial effects in an external magnetic field. The results apply particularly to new high-temperature superconductors with a critical temperature about 90K and a coherence length only 30-50 times larger than the lattice  $a$ -parameter in magnetic fields of 0.1-10 T intensity. The authors thank I.F. Shchegolev and O.G. Novik for pointing out that impurities of the Fe group settle preferentially in Cu-O chains. Figures 4; references 17: 5 Russian, 12 Western (1 in Russian translation).

### Josephson Current in a SNINS Junction

18620184B TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian Vol 77 No 3, Dec 88 pp 450-459

[Article by L. N. Akhramovich, Yu. Rakov, and A. V. Svidzinskiy]

[Abstract] This study employs fitted equations to analyze the current states in a superconducting SNINS junction for the case of random transparency of the dielectric interlayer in the N-layer. Two techniques are used to solve the problem. The first method employs a system of equations for the Green's functions of the superconductor which represents a specific type of fitted equations for the Green's functions with noncoincident arguments. The second method utilizes equations with noncoincident values of the arguments and the "gluing" of the Green's functions in two linearly independent solutions.

**What Happens When Electrical Conductivity of Film Is Higher Than Speed of Light**

*18620216C Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 6, Jun 89 (manuscript received 29 Dec 88, after revision 21 Feb 89) pp 1988-1992*

[Article by V.I. Falko and D.Ye. Khmelnitskiy, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] Nondissipative plasma oscillations and dissipative Maxwellian charge relaxation in a film are analyzed, considering that charge relaxation involves spreading of charge at a speed equal to  $2\pi$  times the electrical conductivity of the film material. The complete system of Maxwell equations for both vector and scalar potentials, with Ohms' law extended to include a wave field term and with the continuity equation, is solved for a two-dimensional layer. When the electrical conductivity is higher than the speed of light (electromagnetic waves), then the solution yields a slowly decaying very-low-frequency plasma wave. The field distribution in such a very long plasma wave is calculated in the form of equiphase surfaces. The coefficients of transmission, absorption, and reflection for a plasma wave polarized in the plane of incidence are calculated, all three coefficients depending on the angle of incidence, whereupon the dispersion law for surface waves on a film is determined from the poles of both reflection and absorption coefficients. The authors thank I.V. Kukushkin and V.B. Timofeyev for formulating the problem, Yu.S. Barash and M.I. Kaganov for interesting discussions. Figures 3; references 4: 3 Russian, 1 Western (in Russian translation).

UDC 530.145

**Are Black Holes Really Black?**

*18620223B Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 32 No 5, May 89 (manuscript received 15 Oct 86) pp 95-97*

[Article by A.A. Grib, Leningrad Institute of Finance and Economics imeni N.A. Voznesenskiy]

[Abstract] The paradox in quantum theory of black holes that "owing to globality of the quantum state inevitably spread beyond the horizon, Bogolyubov transformations accounting for restructurization of vacuum can yield to an observer information from under the horizon" is resolved on the basis of analogy to the Einstein-Podolsky-Rosen paradox pertaining to transmission of information at a speed higher than the speed of light. The quantum-mechanical principle of complementarity between whole and part is applied to a system consisting of two subsystems and describable by a pure state, each subsystem being describable by a density matrix if the wave function of the system is not a product of the wave functions of its subsystems. An inertial observer moving with a constant acceleration in a Rindlerian reference system perceives vacuum as a mixed state with a density matrix which describes the temperature distribution. Such an observer measuring one subsystem and knowing about existence of the other will conclude that the entire system is describable by a density matrix. Generation and annihilation operators for "left-hand" or "right-hand" particles must, therefore, be expressed through operators for which the corresponding density matrix rather than vacuum plays the role of Fokian vacuum and this can be done by means of Bogolyubov transformation. Calculations for Hawking radiation from a black hole indicate that correlations between readings taken by observers on both sides of the horizon cannot be detected by one observer and thus from one subsystem alone. Accordingly, and because there is no contradiction with the causality principle, black holes do remain black. The author thanks N.Sh. Urusova for discussion. References 6: 1 Russian, 5 Western (1 in Russian translation).

UDC 62-50

**Differential Game With Fuzzy Target Set and Fuzzy Initial Positions**

18620141 Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 53 No 1, Jan-Feb 89  
(manuscript received 4 May 88) pp 60-65

[Article by V. A. Baydosov (deceased), Sverdlovsk]

[Abstract] A differential two-player game  $x^*$  function of  $t, x, u, v$  is considered with  $x$  in  $R^n$ ,  $u(t)$  in  $P$ ,  $v(t)$  in  $Q$ , and compacts  $P, Q$  in  $R^p, R^q$  respectively. Assuming that the condition of a saddle point is satisfied for a small game, a universal optimum strategy is built for controlling a

fuzzy given set of objects in the presence of interference so as to ensure that at a certain instant of time this set either approaches or evades a fuzzy target set of positions. The necessary condition for solvability is established for the approach problem and for the evasion problem, this condition also being the sufficient one in each case when a universal optimum strategy for solving the respective problem exists. The game has a saddle point when the payoff function, membership-in-target-set function in this game, is continuous. When it is semicontinuous, with an upper limit or a lower limit, then only one of the players has an optimum strategy and respectively either only approach or only evasion from a fuzzy initial position is relevant. The author thanks A. I. Subbotin for discussion and comments. References 6: 4 Russian, 2 Western.

**Optimum Trajectory Fields Containing Second Order Singular Extremals and Extremals With Faster Trajectories**

*18620158A DOKLADY AKADEMII NAUK SSSR in Russian Vol 304 No 5, Feb 89, pp 1050-1053*

[Article by M. I. Zelikin, V. F. Borison]

[Abstract] This study investigates the behavior of solutions of discontinuous Hamiltonian systems in the vicinity of the manifold of second order singular trajectories. It is proven that there are two manifolds of codimensionality 2 stratified into piecewise-smooth two-dimensional layers (each of which contains specific trajectories with faster switches) in the vicinity of the manifold of the second order singular trajectories.

UDC 518.5

### Intricacy of Computing Genus of System of External Differential Equations

18620202 Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 306 No 1, May 89 (manuscript received 2 Dec 87) pp 26-30

[Article by D. Yu. Grigoryev, Leningrad Department, Institute of Mathematics imeni V. A. Steklov, USSR Academy of Sciences]

[Abstract] An algorithm is constructed for computing the genus of a system of external differential equations, this algorithm requiring less computation time than elimination of quantors in accordance with first-order theory of closed algebraic fields. Into account is taken existence of integral manifolds which satisfy a given system of such equations of any dimensionality not larger than its genus, according to the Cauchy-Kowalewska theorem. A system

$f_i^{(0)}(X_1, \dots, X_n)$  equal 0

$f_i^{(m)}$  identical to  $1/m! \sum A_{J,i} dX_{j_1} \dots dX_{j_m}$  equal 0 if not smaller than 1 and not larger than  $k m$  not smaller than 1 and not larger than  $n$

is considered, where coefficients  $A_{J,i}$  are cosymmetric with respect to poly-indices  $J$ . The dimension  $1(p/q)$  of any rational number  $p/q$  in the field  $Q$  of polynomials  $X$  is expressed in  $\log_2(pq+1) + 1$  bits,  $1(f_i^{(0)})$  then denoting the largest among dimensions of its coefficients. Both dimensions  $1(f_i^{(0)})$  and  $1(A_{J,i})$  are assumed to be not larger than some natural number  $M$ . A theorem is proved, with the aid of a lemma, which states that the characters as well as the genus and thus also the global genus of this system of equations can be computed within a time  $M k(dn)^{n^4} \alpha^{(1)}$ . Article was presented by Academician L. D. Faddeev on 26 November 1987. References 7: 5 Russian, 2 Western (both in Russian translation).

UDC 517:513.88

### Asymptotic Behavior of Solutions to Weakened Cauchy Problem for Differential Equation With Variable Unbounded Operator in Banach Space

18620249A Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 41 No 6, Jun 89 (manuscript received 28 Aug 86) pp 762-769

[Article by G. K. Roginskiy, Scientific Research Institute of Analytic Adaptive Systems, UkrSSR State Committee for Construction, Kiev]

[Abstract] The differential equation  $dx/dt = A(t)x$  ( $t$  from 0 to infinity) in a Banach space  $E$  is considered,  $A(t)$  denoting a linear unbounded operator with a dense domain which is independent of  $t$  and in which it is strongly continuous. A bounded inverse operator  $A^{-1}(t)$  is assumed to exist. The weakened Cauchy problem for this

equation, correct in  $D(A)$  with an evolution operator  $U(t,s):E$  into  $E$  ( $s$  from 0 up but smaller than  $t$ ) bounded at all  $t$  and  $s$ , is analyzed for the asymptotic behavior of weakened solutions to that equation. Upon introduction of the equation  $dx/dt = A(t_0)x$  ( $t$  from 0 to infinity), where  $A(t_0)$  denotes a "frozen in time" coefficient, three definitions are introduced and two statements are proved pertaining to a compact operator-function  $A(t)$ . Three theorems are stated and proved pertaining to the general index of the weakened Cauchy problem, which determines the behavior of its solutions. The last of these theorems extends to the nonhomogeneous equation  $dx/dt = A(t)x + f(t)$ . References 4: 2 Russian, 2 Western (both in Russian translation).

### The Limit Cycles of a Dynamical System Modeling Laser Operation

18620183B Minsk DIFFERENTIALNYYE URAVNENIYA in Russian Vol 25 No 3, Mar 89 pp 540-542

[Article by V. A. Rantsevich and A. M. Samson]

[Abstract] This study employs differential equations in an analysis of the limit cycles of a dynamical system modeling laser operation. The analysis establishes the parameter spaces in order to help determine the number of stable equilibrium states of laser operation. Computer calculations show that by varying the parameter  $v$  it is possible to obtain a variety of combinations of stable and unstable equilibrium points if there are three such points (the center point is always the saddle, while in the case of three states it is possible to change the type of stability). The study also determines the conditions for the transition of the domain of three equilibrium states to the domain of a single state and vice versa.

UDC 539.2

### Umklapp Solitons in New Integrable Two-Dimensional Equations

18620243A Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA MATEMATICHESKAYA in Russian Vol 53 No 2, Mar-Apr 89 (manuscript received 26 Dec 88) pp 243-257

[Article by O. I. Bogoyavlenskiy]

[Abstract] Two new two-dimensional nonlinear partial differential equations integrable by the method of a one-dimensional inverse scattering problem are arrived at, their soliton and N-soliton solutions being smooth in one coordinate and having the Umklapp property of a classical Riemann wave in the other one. Both equations are derived from the Lax equation  $L_t$  equal to  $[L, A]$ , where  $[L, A]$  is the commutator of the Schroedinger operator  $L$  and a third-order skew-symmetric operator  $A$ . Following the proof of existence of an exact solution, an Umklapp soliton, exact solutions in the form of Umklapp N-solitons are obtained upon consideration of the Cauchy problem. Each of the two new equations is

equivalent to a more general operator equation  $L$  equal to  $P(L)$  plus  $[L, A]$ ,  $A$  being another third-order operator for the first equation and the sum of both for the second equation. In addition to the two existence theorems for exact soliton solutions are also proved a theorem which establishes complete integrability of the Euler equation  $L$  equal to  $[L, A]$  and a theorem which admits Lax representation of a two-dimensional partial differential equation. References 9: 5 Russian, 4 Western (1 in Russian translation).

### Interaction of Finite Solitary Waves for Equations of Born-Infeld Type

*18620232A Moscow TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian Vol 78 No 1, Apr 89 (manuscript received 7 Sep 87) pp 16-29*

[Article by O. F. Menshikh, Kuybyshev Institute of Aviation]

[Abstract] A class of quasi-linear second-order partial differential equations in two independent variables  $x, t$  is constructed, a generalization of the Born-Infeld equation, equations which have two exact solutions with a variable coefficient each: a finite function describing a plane solitary wave. Inasmuch as the Born-Infeld equation in the hyperbolic region reduces to a special system of first-order partial differential equations in Riemann invariants, such a description is sought for this class. Both the Cauchy problem and the problem of two-wave interaction, the two finite plane waves passing through one another, are solved from this standpoint with the aid of two theorems. The first theorem establishes the necessary and sufficient conditions for reducibility to Riemann invariants. It is followed by four corollaries and nine propositions, the last one that an equation of the given class can be rewritten into a conservation law leading to the second theorem. This one establishes the availability of a local transformation, a special case of the Baecklund transformation, for transforming any equation in the given class to another one in this class. All the propositions having been proved, three other equations in this class are shown besides the Born-Infeld equation and including the Chaplygin equation which describes one-dimensional nonsteady isentropic flow of a gas. The author thanks B. M. Barbashov, B. A. Dubrovin, B. L. Rozhdestvenskiy, and A. B. Shabat for support and for discussion of the results. References 15: 13 Russian, 2 Western.

UDC 621.373.826:681.7.068

### Laser-Type Acoustic Transducer

*18620233B Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 35 No 4, Jul-Aug 89 (manuscript received 5 Nov 88) pp 747-749*

[Article by G. N. Belova and P. V. Soldatov, Institute of Acoustics imeni N. N. Andreyev, USSR Academy of Sciences]

[Abstract] An acoustic transducer is described which contains an injection laser for optical processing of sound signals through an acoustically Q-switched external cavity. Such an experimental transducer was built with a multimode continuous-wave AlGaAs-laser (wavelength 850 nm), the semiconductor crystal having opposite faces specially coated for high reflectance (0.98) and low reflectance (0.04) respectively. A 30 cm long external cavity was formed by a plane mirror, one with a 0.5 reflection coefficient and one with a 1.0 reflection coefficient having been used in the experiment. Two lenses were placed inside the cavity between the low-reflectance crystal face and the plane mirror, the first one (focal length 6 mm, NA 0.2) collimating the laser radiation and the second one (focal length 4 mm, NA 0.4) at the end of a piezoceramic tube then focusing the laser radiation onto the mirror. The tube could be moved so as to make the plane of the mirror initially coincide with the focal plane of the lens and then separate the two planes by a variable distance. Transverse vibrations of the mirror along the cavity axis, with the amplitude varied up to 0.015 mm and the frequency varied over the 0.5-42 kHz range, were excited by piezoelectric device. Such vibrations modulate the intensity of the laser radiation, the modulation factor depending on both amplitude and frequency of mirror vibrations. The modulated laser radiation is converted by a photodiode into electric signals. Modulation at the frequency of the acoustic signal was found to ensure higher sensitivity, a lower sensitivity threshold, with less distortion than modulation at twice that frequency. The authors thank V. L. Velichanskiy and A. S. Zibrov for helpful suggestions. Figures 2; references 6: 2 Russian, 4 Western.

### Pseudodifferential Equations in Functional Superanalysis. II. The Feynman-Katz Formula

*18620183A Minsk DIFERENTIALNYYE URAVNENIYA in Russian Vol 25 No 3, Mar 89 pp 505-514*

[Abstract] This article derives a representation of solutions (superanalogs) of the heat conduction and Schrödinger equations with the potential represented as continual integrals in the trajectory space with values in the superspace. The most important difference between the formula derived here and the ordinary Feynman-Katz formula is the chronologic exponent of the potential.

UDC 517.11

### Iterative Nonstandard Enlargements in Topology

1862018A Novosibirsk SIBIRSKIY  
*MATEMATICHESKIY ZHURNAL* in Russian  
Vol 30 No 3, May-Jun 89 (manuscript received  
10 Nov 87) pp 64-71

[Article by V.A. Molchanov, Saratov]

[Abstract] The theory of monads, including monad interpretation of filters and ultrafilters, is applied to non-standard enlargements for nonstandard description of topologies. First is proved a theorem stating the condition for a perfect map of a subset of individuals in another. Then there are proved a theorem stating the condition for a monadic correspondence to be a topology, with two corollaries pertaining to compacts, and a theorem stating the condition for a monadic correspondence to be a regular topology. With the aid of a lemma are proved two compaction theorems, one stating that compactifications of any topological space are factor-spaces of its nonstandard enlargement and one leading to a corollary about exact compaction. Next iterative nonstandard enlargements are applied to complements of uniform spaces, definition of such a complement being followed by proof of a theorem defining the functor of the category of uniform spaces and uniformly continuous maps into the category of complete uniform Hausdorff spaces and uniformly continuous maps. References 11: 5 Russian, 6 Western (1 in Russian translation).

### Classification of Finite Motions of Particle in Kerr Metric

18620138F Moscow ZHURNAL  
*EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI* in Russian Vol 95 No 2, Feb 89 (manuscript  
received 11 May 88) pp 385-390

[Article by A. F. Zakharov, Institute of Theoretical and Experimental Physics]

[Abstract] The five types of finite motion of a particle along the r-coordinate relative to a rotating black hole, describable by the Carter equations and thus by the first integrals in the equations of geodesics, correspond to  $R(r)$  polynomials which have respectively one single root, three single roots, a smaller single root and a larger double root, a smaller double root and a larger single root, and one triple root. When the rotation of the black hole is extreme limiting, then the five types of finite motion of a particle with an energy squared larger than  $\frac{1}{2}$  and an angular momentum relative to the z-axis equal to twice the energy correspond to  $R(r)$  polynomials which have respectively a smaller double root and a larger single root, one triple root and one single root, one double root and two single roots, two double roots, and one double root. On the basis of this classification are determined stable, unstable, and impossible finite radial

motions of a particle first in the Schwarzschild metric and then in the Kerr metric. Sets of constants corresponding to each type of motion are determined topologically and invariants are found which do not depend on the rotational constant of the metric. The author thanks V. S. Imshennik for interest, S. I. Blinnikov, I. D. Novikov, A. G. Polnarev, and D. G. Yakovlev for valuable discussions. Figures 3; references 19: 10 Russian, 9 Western (5 in Russian translation).

### Symplectic Topology of Completely Integrable Hamiltonian Systems

18620142B Moscow USPEKHI  
*MATEMATICHESKIH NAUK* in Russian  
Vol 44 No 1 (265), Jan-Feb 89 (manuscript received  
8 Feb 88) pp 145-173

[Article by A. T. Fomenko, Moscow State University imeni M. V. Lomonosov]

[Abstract] Following a review of definitions pertaining to Hamiltonian systems of differential equations and the Kolmogorov-Arnold-Moser theorem, a symplectic topology of Hamiltonian systems completely integrable with Bott integrals is constructed on the basis of a 4-dimensional theory. This involves classification of isoenergetic surfaces on which such Hamiltonian systems are nondegenerate, consideration of topological obstacles to integrability, and establishment of the condition for a compact 3-manifold being an isoenergetic surface. It further involves particularization of Morse's theorem for Bott integrals on isoenergetic surfaces, only five kinds of 3-manifolds being possible for these integrals, graph representation of isoenergetic surfaces, and classification of Liouville tori. There follows canonical restructurization of Liouville tori in the multi-dimensional case. Topological invariants of Hamiltonian systems integrable with Bott integrals are found and component elements of an isoenergetic surface are classified in the case of a composite integral. Equivalent second definitions of graph and surface are given, whereupon isoenergetic invariants are calculated for Kowalewska, Goryachev-Chaplygin, and Sretenskiy cases. General topological properties of Hamiltonian systems integrable with Bott integrals are expressed in the form of theorems, one of them stating that the four (H), (Q), (W), (S) classes of 3-manifolds are congruent. A lower estimate is established for the number of stable periodic solutions to such systems of differential equations and this lower estimate is associated with existence of exact round Morse functions, considering that in most cases Bott integrals are also round Morse functions. Mention is made of Hamiltonian mechanics and hyperbolic manifolds. The author thanks S. P. Novikov, V. I. Arnold, D. V. Anosov, V. V. Kozlov, and Ya. V. Tatarinov for helpful discussions at the seminar on "Geometry and Mechanics" held at the Moscow State University. Figures 11; references 53: 39 Russian, 14 Western.

**The Tangential Properties of Topologic Spaces**

*18620123A Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA: SERIYA 1, MATEMATIKA, MEKHANIKA in Russian No 2, Jan-Feb 89 pp 26-29*

[Article by A. V. Arkhangelskiy, B. M. Bokalo ]

[Abstract] The "Tan" tangency relation is determined in a family of topologies represented in the set X. Certain specific tangential properties of topologic sets are discussed and relations of other cardinal invariants of tangential topologies in X are also investigated.

**Fractals in Lyotropic Systems**

*18620163A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 14 No 23, Dec 88 pp 2204-2207*

[Article by R. I. Mints, S. A. Skopinov, S. V. Yakovleva]

[Abstract] This study employs polarization microscopy to investigate fractal structures in water-salt-protein systems and identifies a fractal crystallization mechanism in such systems attributable to the phase stratification of the sodium and organic components of the solution. Water-NaCl-albumen and water-NaCl-protein solutions were used. In the test concentration ranges used in this study, these solutions are comparable to several biological fluids. In order to investigate crystallization a droplet of the solution was deposited onto a glass substrate pretreated with a weak lecithin solution. The derived specimens were maintained at a temperature of 20 plus or minus 0.5°C in darkness in a 400 cm<sup>3</sup> chamber for 24 hours. It is determined from an analysis of these specimens that cubic NaCl crystals with dislocation growth traces form in systems with allow protein concentration. The analysis also suggests that the cubic NaCl crystallite dimensions are greater during the dislocation growth stage the lower the relative protein concentration. The overall test results show that a fractal growth mechanism exists in aqueous saline-protein solutions; this mechanism is not the direct result of crystallization nonequilibrium, but rather occurs due to the spatial inhomogeneity caused by the phase stratification of the salt and the protein.

**Some Classes of Nearly Compact Homogeneous Spaces**

*18620156B Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 4, Nov 88 (manuscript received 1 Jun 87) pp 785-788*

[Article by V.V. Gorbatevich, Moscow Institute of Aviation Technology imeni K.E. Tsiolkovskiy]

[Abstract] A new class of homogeneous spaces is described which includes not only all compact ones but also all quasi-compact ones. Following the definition of a uniform envelope for a closed plesiouniform subgroup H

in a singly-connected topological Lie group, seven evident theorems with two corollaries and three propositions are stated pertaining to such spaces. Article was presented by Academician S.P. Novikov on 1 Jun 1987. References 12: 9 Russian, 3 Western (1 in Russian translation).

**The C<sup>r</sup> Closing Lemma on Surfaces**

*18620109B Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 5 (263), Sep-Oct 88 pp 173-174*

[Article by S. Kh. Aranson, Ye. V. Zhuzhoma]

[Abstract] This article focuses on the C<sup>r</sup> closing lemma initially developed by Pew. This note identifies a class of open Poisson-stable half-trajectories of vector fields on closed two-dimensional surfaces M<sup>2</sup> of the kind p is greater than or equal to 2 for which the C<sup>4</sup> closing lemma holds for any r is greater than or equal to 1.

**Topologic Invariants of Liouville-Integrable Hamiltonian Systems**

*18620104A Moscow FUNKTIONALNYY ANALIZ I EGO PRILOZHENIYA in Russian Vol 22 No 4, Oct-Dec 88 pp 38-51*

[Article by A. T. Fomenko]

[Abstract] This article analyzes systems in 4-dimensional symplectic manifolds. The study uses an earlier formulation of a Morse-type theory to develop a new topologic invariant of integrable systems: a graph, a two-dimensional surface, and an imbedding; in the nonresonant case all these objects will be independent of the selection of the auxiliary integral and consequently will describe the integrable case itself (the Hamiltonian). The study demonstrates that this invariant is easily calculated. It is calculated for several classical integrability cases of equations of motion of a heavy solid, including the Kovalevsky, Goryachev-Chaplygin, and the gyrostat cases. The study also derives an explicit formulation of the invariants, several select theorems and proofs.

**Weighted Displacement Operator in a Topologic Markov Chain**

*18620104B Moscow FUNKTIONALNYY ANALIZ I EGO PRILOZHENIYA in Russian Vol 22 No 4, Oct-Dec 88 pp 86-87*

[Article by Yu. D. Latushkin, A. M. Stepin]

[Abstract] This note establishes the relationship between the spectral radius of a weighted displacement operator in the space  $L_p = L_p(x, \mu)$  and the entropy characteristics of a topologic Markov chain and describes the spectrum of  $T_g$ . The spectral radius of  $T_g$  is obtained in  $L^m_2(x, \mu)$  is derived and it is noted that this formula has been previously found of the case of an invariant  $\mu$ .

**Condition for Unitarity in Covariant Quantum Field Theory With Indefinite Metric**

18620238A Moscow TEORETICHESKAYA I MATEMATICHESKAYA FIZIKA in Russian Vol 79 No 3, Jun 89 (manuscript received 21 Jun 88) pp 347-358

[Article by A. A. Slavnov, Institute of Mathematics imeni V. A. Steklov, USSR Academy of Sciences]

[Abstract] The condition  $Q/\Phi = 0$  for existence of a unitary scattering matrix is established in the BRST quantization formalism for covariant quantum field theories, following extraction of the physical subspace and calculation of the norm of physical states in it. As two examples are considered construction of the Yang-Mills theory and description of a non-Abelian antisymmetric field. Figures 2; references 8: 2 Russian, 6 Western.

UDC 517.982

**Comparison of Topologies Generated by Geometrical and Operator Openings in Subspaces**

18620250A Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 41 No 7, Jul 89 (manuscript received 17 Nov 86) pp 929-933

[Article by M. I. Ostrovskiy, Institute of Low-Temperatures Engineering Physics, UkrSSR Academy of Sciences, Kharkov]

[Abstract] Topologies generated in space  $G(X)$  of all closed subspaces of an infinite-dimensional Banach space  $X$  by, respectively, a Crane-Krasnoselskiy-Milman geometrical opening and by a Massera-Sheffer operator opening  $r$  are compared on the basis of a theorem with a corollary, the latter stating that topology  $(G(X), r)$  is a strict majorant of topology  $G(X)$ , for  $X = C(\Omega)$  ( $\Omega$ -compact) and for  $X = L_{p(\mu)}$  ( $p$  from 0 to infinity except 2). For a proof of the theorem, the latter is split into two propositions. The first one, splicing finite-dimensional "pieces" into infinite-dimensional spaces, is proved directly. The second one, constructing suitable finite-dimensional "pieces" in spaces which satisfy the conditions of the theorem, is proved with the aid of a lemma. References 7: 1 Russian, 6 Western (1 in Russian translation).

**Deformation of Morse Functions. Part 1**

18620180A Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 41 No 2, Feb 89 pp 237-243

[Article by V. V. Sharko]

[Abstract] This study analyzes exact Morse functions (functions with a minimal possible number of critical points) in singly-connected compact manifolds. Three classes of deformations of Morse functions are given: homotopic, isotopic, and conjugate. The necessary and sufficient conditions for the existence of the corresponding deformation between two exact Morse functions are established.

**Topological Constraints on Quasicrystals**

18620216D Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 95 No 6, Jun 89 (manuscript received 31 Jan 89) pp 2249-2258

[Article by P.A. Kalugin and L.S. Levitov, Institute of Theoretical Physics imeni L.D. Landau, USSR Academy of Sciences]

[Abstract] Quasicrystals, describable as continuous or discontinuous periodic structures in a more than three-dimensional space according to a model such as the Frenkel-Kontorova model, are shown to be describable as quasi-periodic structures in a d-dimensional space with  $d'$  noncommensurate space frequencies and accordingly by a family of  $d'$ -dimensional surfaces forming a periodic array in a D-dimensional space  $R^D$  where D equals  $d$  plus  $d'$ . Dimensionality  $d'$  of the phase space being equal to dimensionality  $d$  of the physical space for all real quasicrystals, the necessary condition for existence of nonintersecting continuous atomic surfaces is established by considering any two such planes. The condition is that the intersection of their respective sublattices contain a nonzero sub-lattice, in this case there being no topological constraint compelling such surfaces to intersect. Symmetries of an icosahedron and a pentagon are analyzed on this basis, two-dimensional quasicrystals (atomic surfaces) with pentagonal symmetry found not to be describable by a continuous model. The authors thank A.Yu. Kitayev for helpful discussions. Figures 2; references 10: 3 Russian, 7 Western.

**Differentiability Conjugations of Diffeomorphisms  
of a Circle With Rotations**

18620142A Moscow USPEKHI  
*MATEMATICHESKIKH NAUK* in Russian  
Vol 44 No 1 (265), Jan-Feb 89 (manuscript received  
19 Jan 88) pp 57-82

[Article by Ya. G. Sinai and K. M. Khanin, Institute of  
Theoretical Physics imeni L. D. Landau, USSR  
Academy of Sciences]

[Abstract] Following a review of concepts pertaining to  
homeomorphisms and diffeomorphisms of a circle, par-  
titions of a circle with rotations are considered in the

light of Denjoy's lemma and theorem. A relation  
between the smoothness of conjugations of circle diffeo-  
morphisms and the positive density of an absolutely  
continuous invariant Lebesgue measure is established as  
a corollary to this theorem, with subsequent Arnold's  
reduction of the problem to solution of a homologous  
equation for the density of such a measure. The funda-  
mental theorem is proved with the aid of six lemmas  
which strengthen Denjoy's inequality. Discussion and  
generalization of the results lead to two additional theo-  
rems, both pertaining to conjugations of diffeomor-  
phisms and sets in which they belong, one proved with  
the aid of five lemmas and the other with the aid of two  
lemmas. References 19: 5 Russian, 14 Western.

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